CSU-OMRC Viticulture Research
Annual Report
July 1997 - June 1998

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Submitted to:

The Colorado Wine Industry Development Board

by
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Outline of the CSU Viticulture Program for July 1997-June 1998

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Introduction:

Within the past decade interest in Colorado wine grapes production has steadily increased and the wine industry has blossomed as a consequence. Wine grape production for 1997 was up to an all time record harvest of 755 tons and a 37% increase over last year. This dramatic increase was a result of a mild winter, more vineyards becoming mature and enhanced skill level. Average production was 3.4 tons per acre. The harvest was much larger than anticipated considering the potentially devastating spring frost that occurred April 12 (17°F)

Twenty-seven more acres were planted to *vinifera* vines in western Colorado where 99% of the vineyards are planted. Self-rooted vines still dominate (98%) the planted acreage and Chardonnay is still the most widely planted (27%) followed by Merlot (24%), Riesling (8%), Cabernet franc (6%) and Cabernet Sauvignon (6%).

Five new wineries became licensed in 1997 raising the total to 21 and increasing the total production capacity to approximately 220,000 gallons.

Colorado offers distinct challenges to its grape growers and winemakers. Its disease and insect pressure, soils, irrigation, micro- and macro-climates are diverse from those of other states and countries, and they require growers and winemakers to consider a different set of solutions than those available to growers in other viticultural regions. Technical assistance and research programs provided by the viticulture program at the Orchard Mesa Research Center are addressing these unique problems and have greatly enhanced the success and confidence of Colorado growers since its inception. The recent CWIDB industry survey found the CSU viticulture program to be in close alignment with the needs and priorities of the industry.

This report is a summary of the activities, accomplishments and results of the viticulture program outlined in the Memorandum of Understanding (MOU) between the Colorado Wine Industry Development Board (CWIDB) and Colorado State University (CSU) for the period of July 1997 through June 1998. Various technical papers, graphs, summaries and Colorado wine industry statistics have been included in the Appendix.

Objectives:

1. Initiate and develop viticultural programs according to the needs of the grape industry
2. Implement these programs with emphasis on grape production
3. Provide growers and vintners with technical assistance
4. Conduct applied research and field demonstrations in grape production

VITICULTURE RESEARCH AND EXTENSION PROGRAM SURVEY
-A SUMMARY AND DISCUSSION-

Summary

In 1997, the Colorado Wine Industry Development Board (CWIDB) directed its research sub-committee to develop a survey to assess the research and extension needs of Colorado wine grape growers and winemakers. The purpose of the survey (copy attached) was to help assure that the CWIDB research and extension program align well with prioritized needs of the Colorado industry.

Eighty-four surveys were mailed, and forty-five (54%) were returned to the Colorado Department of Agriculture (CDA); of these, thirty-five were from growers and ten from licensed wineries. The survey results were tabulated by CDA personnel who provided the attached compilation.

Part I: Viticulture. This was the most comprehensive part of the CWIDB survey, and provided the clearest picture of industry needs. The ratings of viticulture program topics fall into three categories of apparently declining priority, i.e. those receiving total scores of 151 - 157, 130 - 141, and 100 - 123.

Specifically, these results show that the most important viticulture research topics for Colorado are disease/pest management and cold hardiness, followed closely by canopy management. Pruning and fertigation/fertilization/nutrition were also identified as top priority research needs. According to the CWIDB survey, the most important extension program topic is "workshops related to growing grapes".

Part II. Enology. This part of the CWIDB survey presented fewer topics to respondents, and, perhaps partly because of this, the ratings separated more clearly. The most important of the enology topics for which total scores were compiled is "Wine making techniques workshops". The only enology research topic to be rated is wine color enhancement research.

The survey section which sought input on "suggested seminar topics" provided a variety of ideas, but is somewhat difficult to interpret in specific ways. However, the top-ranking ("5") set of suggestions from survey respondents divides rather evenly into two broad categories of "Workshops related to growing grapes" and "Wine making techniques workshops".

Part III

1. What assistance do you want from the viticulturist?

This first question in Part III of the survey generated many answers from the respondents. Close examination of these shows that most are of two broad types, identifying topics for either research per se or technical assistance. Of the research topics, the same ones which were indicated to be of highest priority in Part I were also identified in this section. These include cold hadriness, pest management, fertilization, and pruning. The consistency between these two parts of the survey, which phrase questions differently, strongly validated the results.

2. Would you be interested in a workshop in which grape growers and winemakers would work together...

A large majority (85%) of those answering this question did so in the affirmative.

3. From all the topics...select and rank the five...

The results obtained in this section of the survey are difficult to summarize in a meaningful way. The responses are placed in categories A. (most important) through E. (less important?). Program elements shown to be of highest priority by responses in Part I. And Part III.1 do appear in A (most important), but some are also listed under B, C, D, and E.

4. Do you have any other comments for the Wine Board and/or Colorado State University?

The answers to this question are diverse and interesting, but do not cluster around specific topics in ways that identify priorities.

Discussion

Since its inception, the CWIDB has directed and monitored its program of research and technical assistance (extension) through close communication with members of the industry and with the viticulturist. Among the primary means of communication have been the annual report of progress; proposal for the subsequent years work; and interactive discussion of these at board meetings each year. The current survey, completed in early 1998, adds another important mechanism of gathering input with which to help guide future decisions.

Although "fine-tuning" adjustments may always be needed, a comparison of the 1998 survey results with objectives of the most recent (1997) project proposal (see attached) shows that this CWIDB program is well aligned with industry needs. Annual adjustments have produced the current distribution of effort between technical assistance (60%) and research (40%). The research objectives of the 1997 program include study of all the high priority research topics revealed by Part I and Part III.1, of the 1998 survey.

The CSU viticulturist has conducted workshops, and these have at times included the participation of national experts who are part of his peer network. The survey results verify the continuing need for workshops on both grape growing and wine-making techniques. An important specific finding of the survey is that another comprehensive wine-making workshop may be needed soon, a possibility to be discussed with the CWIDB and the RMAVV.

The capacity and responsiveness of the CSU viticulture program reflects the institution's land-grant mission and tradition. Colorado State's agricultural research and extension programs have focused on industry needs for more that a century, and the CSU viticulture program is part of this tradition. As Colorado's only land-grant university, CSU has a mandate to conduct research and extension programs that enhance the quality of life for its citizens. In carrying out this mandate for so long, CSU has developed unique capacity to meet needs of the wine industry. Elements of this capacity include its:

- Commitment to field research, and a system of off-campus research centers. The presence of research centers makes CSU very much a local institution in places like Grand Junction. The infrastructure and support staff at the Orchard Mesa Research Center are important to the success of the program.

- Ready availability of CSU colleagues with expertise in supporting disciplines such as plant pathology, entomology, food science, plant physiology, soil science, etc., etc.

- Graduate program. Graduate student thesis research is a cost effective way of expanding the overall program.

- CSU Cooperative Extension network for disseminating information. This includes the wine grape section of the Fruit Growers Newsletter, and the Grape Growers Guide - a major production manual.

- Role as a participant in numerous networks and partnerships for research and extension that combine county, state, and federal resources/expertise.

The CWIDB can take pride in having developed and managed an effective and on-target program of research and technical assistance. Continued adjustments in response to well-communicated needs will help assure that Colorado's wine industry will maintain its impressive growth.

Climatic Overview and Year End Summary

In spite of near record rainfall, wine grape production for 1997 was up to an all time record harvest of 755 tons and a 37% increase over last year. This dramatic increase was a result of a mild winter, more vineyards becoming mature and enhanced skill level. Average production was 3.4 tons per acre. The harvest was much larger than anticipated considering the potentially devastating spring frost that occurred April 12 (17°F). Average monthly mid-winter low temperatures for the Grand Valley Viticultural Region (elevation 4500 ft.) were 2 to 7° warmer than the 30 year average. The first fall frost occurred on October 13 (26°F) and was two weeks earlier than normal. As a result of this fall frost, a slight reduction in fruit quality of late maturing varieties was reported. Rainfall was abnormally high for this area with 12.9 inches compared to the normal of 6.2 inches for May-October. The high rainfall and relative humidity during the ripening period created a much greater incidence of mildew infection and was noted by several winemakers. Insect pressure was primarily limited to a few out-breaks of grape mealybug (*Pseudococcus Maritimis*) and continues to be increasing it's population in the Colorado wine growing region.

The date of bud break was normal for most *vinifera* of the region and began April 25 and ended May 10. The total cumulative growing degree days (April 1-October 31, 50°F base) for 1997 was slightly warmer (3451) than the 30 year average (3328). Harvest was two to three

weeks later than normal and was attributed to the above average rainfall during the September-October period. With the exception of the higher incidence of mildew, the overall fruit quality was approximately $1190 with a range of $800 for Riesling to over $1500 for Cabernet Sauvignon. Handpicking costs average $115 per ton

See the Colorado Wine Grower Survey in the Appendix for further variety specific details.

Technical Support:

The CSU viticulture program provides technical support to the Colorado Wine Industry through site visits, research center tours, newsletters, surveys, telecommunications, workshops technical advice on site selection, vineyard development, winery development and cultural management is provided throughout the year upon request. Viticulture and enology related phone calls e-mail, faxes, and personal visits continue to increase and are a big avenue of technical support and continue to increase. This technical support provides a means of one to one communications that has been unsurpassed with industry satisfaction. During this 12-month contractual period the CSU viticulturist answered over 600 phone calls and made more than 200 personal grower contacts via vineyard site visits or grower research center visits. Tours of the research center vineyards and enology lab were arranged for individuals, visiting scientists, and groups upon request.

The 1997 Colorado Wine Grower Survey was mailed to approximately 70 growers, compiled in December and the results were published in the CSU Cooperative Extension Fruit Grower Newsletter and mailed to all participating growers. The Wine Grower Survey provides average industry production information that is highly useful for the current and future industry projections.

Technical support was also provided via newsletters. The Colorado Grapevine is a newsletter column published bi-monthly in the CSU Cooperative Extension Fruit Growers Newsletter. The Colorado Grapevine was first published in 1991 and contains various articles of technical value for grape growers, vintners and the public at large. Articles published for the July 97 – June 98 period include the following:

1) "Record Keeping in the Vineyard" – Vol. 17-4

2) "How to Estimate Grape Yields" – Vol. 17-5

3) "Powdery Mildew" – Vol. 17-6

4) "Bud Break and Harvest Dates for 34 Cultivars and Rootstocks and the Grower Survey Results – Vol. 18-1

5) "Vineyard Growth and Fruit to Wood Ratios" – Vol. 18-2

6) "Grape Powdery Mildew Trials" – Vol. 18-3

The first publication of "Vineyard News", a newsletter for supplying practical wine grower information, was mailed out June 3, 1998. This newsletter was created to help supply more technical information specifically to growers at critical times during the year. This newsletter has been very well accepted.

Seminars and workshops provide technical support to larger groups and are extremely well received and attended by many. In September, 75 people attended the Colorado Mountain Winefest wine industry seminar. This seminar focused on the basics of wine growing in Colorado and the current status of the industry. An educational booth/display was set up in the Palisade Park during the Winefest. Over 3500 people attended the Winefest and many of those attendees visited the booth with questions about growing grapes, making wine or the wine industry in general. A technical seminar on Powdery Mildew was presented to 80 growers at the November RMAVV meeting. In January a technical seminar on irrigation management was presented to the Colorado Agricultural Experiment Station at the CSU main campus in Ft. Collins, CO. A viticulture seminar was presented February 5, 1998 to 125 Master Gardeners enrolled in the Tri-River CSU Cooperative Extension Program. "Hands on" pruning/training workshops were held at OMRC in February and March with over 65 attendees at each program.

Field Trials – *Mealy bug*

The grape mealybug Pseudococcus maritimus was first identified in 1994 in vineyards of western Colorado by B. C. Kondratieff and W. Cranshaw Department of Entomology, Colorado State University. Populations of the grape mealybug have increased during the last three years and it has become a production threat to vineyards of western Colorado.

In April of 1997 a mealybug research/demonstration plot was established in a commercial vineyard near Palisade, Colorado. The project was a cooperative effort between the Orchard Mesa Research Center Viticulture Program, CSU Cooperative Extension entomologist Gene Nelson and Grande River Vineyards. Four insecticides currently registered for use on grapes were applied to determine optimum time of application and which chemical performed the best. Each plot was replicated four times in a randomized complete block design. Spray dates were May 1 and May 15, 1997. Theses dates were chosen to bracket the mealybug crawler stage. The crawler stage is considered to be the most vulnerable stage for insecticide efficacy. The insecticides used were Lorsban 4E at 4 pints per 300 gallons, Diazinon 50W at 1.5 pounds per 100 gallons, Provado 1.6E at 5 fluid ounces per 100 gallons, Guthion 50W at 1 pound per 100 gallons and a check treatment (no spray).

The treatments were evaluated on June 5. Mealybug presence was measured by counting excrement droplets on a two foot length of drip tube located underneath the canopy of each vine. Evaluations were as follows:

May 1 Mealybug Evaluations

Treatment	Replicates				Total
	I	II	III	IV	
Provado	16	9	13	10	48
Lorsban	11	11	7	18	47
Guthion	14	7	3	23	47
Diazinon	19	12	4	12	47
Check	15	3	26	28	72
					261

May 15 Mealybug Evaluations

Treatment	Replicates				
	I	II	III	IV	Total
Provado	18	10	18	6	52
Lorsban	18	5	3	28	54
Guthion	4	14	11	11	40
Diazinon	6	15	9	17	47
Check	7	10	17	25	59
					252

The results of this trial demonstrated no differences between treatment dates or insecticides. All plots were re-examined on June 30 and there was no evidence of any excrement residue. Mealybugs were not present on the treated vines or control vines. The lack of mealybugs was a surprise and somewhat of a mystery. Any conclusions based on the results of this trial would be meaningless and confusing. A repeated study would be helpful and may provide more conclusive evidence of insecticide efficacy. Currently we are studying the life cycle of the mealybug to identify egg laying, crawler and adult stages.

Field Trials – *Nematode Survey*

The importance of plant parasite nematodes as causal agents of plant diseases in Colorado is little understood. In 1995 the Colorado Agricultural Experiment Station and the Colorado State Cooperative Extension Service provided support to initiate a survey to identify major plant parasitic nematodes attacking Colorado crops and to obtain information on the distribution of these nematodes in Colorado. The CSU Viticulture Program, Extension Specialists, county agents and numerous private individuals collected samples using standardized procedures and provided historic data for incorporation in the survey database.

Samples were collected from 3 vineyards in Mesa County during 1996 and 1997 and were analyzed in the Nation Resource Ecology Laboratory on the CSU campus under the leadership od Dr. Diana Freckman and Dr. Robert Niles. Ten different nematode species were

identified in soil samples collected from the 3 vineyards in Mesa County. See the appendices for a more detailed description of the 1996-1997 nematode survey.

1997 Powdery Mildew Trials at OMRC:

Powdery mildew (Uncinula necator) is the most serous disease of wine grapes in Colorado. Infection can occur in most vineyards if control measures are not employed. Powdery mildew can lower wine quality; consequently, most wineries will financially penalize a grower or deny the entire load if appreciable mildew is present. Powdery mildew (PM) is easy to control if proper timing of fungicide application is observed. Powdery mildew prevention must occur before the fungus is actually visible. Waiting until visible signs of the fungus forms on the leaves or clusters is too late to prevent infection. The most highly recommended fungicide programs for grape powdery mildew control begin at bud break and continues on a rigid schedule. Starting your fungicide program too late or having long spray intervals are powdery mildew management mistakes that should be avoided. The 1996 Colorado Grape Growers Guide has a powdery mildew schedule that if followed will provide proper management of PM infection in your mature vineyard.

The viticulture program at OMRC has been evaluating several alternative bio-control materials for grape powdery mildew control. Chemical control of PM in Colorado vineyards has been focused on two classes of fungicides, inorganic sulfur as wettable powder formulations and DMI (demethylation inhibitor) fungicides (Bayleton, Nova, Rubigan, etc.). Theses fungicides have worked well for most vineyards but some drawbacks such as, sulfur phytotoxicity, decreased sensitivity of powdery mildew to DMI fungicides and the continued loss of fungicides from EPA regulations have inspired us to set up this small grape powdery mildew trial.

This field trial was established at OMRC in the 6 year old Chardonnay test vineyard. The vineyard has a row by vine spacing of 10' X 5' and was spur-pruned and trained to bilateral cordons on a vertical shoot positioned trellis. All plots were established in a randomized complete block design with 3 replications of 40 vines each.

The chemicals applied, rate, timing of application, cost per acre, and percent infection (leaf, cluster, and cane) are shown in table 1. All treatments were applied using an over the row tunnel sprayer operating at a pressure of 150 psi. The treatments and spray intervals consisted of the following: M-Pede (Mycogen Corp., San Diego, CA) at a12 -14 day interval, sunflower oil (International Flora Technologies, Apache Junction, AZ.) at a 12-14 day interval, Stylet Oil (JMS Floral Farms Inc., Vero Beach, FL.) at a 12- 14 day interval, micronized sulfur (Thiolux by Sandoz Ltd.) at a 10 - 14 day interval, and Nova (Rohm and Haas Co.) at a 14 - 18 day interval. Treatments began at the initiation of shoot elongation (May 14) and continued through the season at 12 - 18 day intervals depending on the fungicide used. All treatments ceased at veraison August 10 and cluster and leaf evaluations were made on August 28, 1997. Dormant canes were evaluated November 5, after leaf fall. Clusters and canes were counted in the field for percent disease incidence of powdery mildew. Disease incidence was expressed as the percent of clusters or canes with any powdery mildew. Leaf powdery mildew incidence was estimated as a percent of whole vine canopy infection.

Table 1. Treatments and results of powdery mildew fungicide trial on Chardonnay grapevines at Orchard Mesa Research Center, Grand Junction, Colorado 1997

Treatment[d]	Rate/100 gals.	Application dates[c]	Powdery mildew (%)[b] Cluster Incidence	Leaf Incidence	Cane Incidence	Cost/acre[a] $
M-Pede	1.5 gal./100	May 14,27, June 12,27 July 14,29, Aug. 8	<1	2.6	3	795
Sunflower Oil + Joy Soap[e]	1.0 gal./100 + 2 oz./100	May 14,27, June 12,27 July 14,29, Aug. 8	1.3	6.5	4.6	118
Thiolux-Sulfur-Nova-DMI	5#/100 2.5 oz./100	May 14,27, June 16, July 8,29, Aug. 8	0	<1	0	44
Stylet Oil	1.5 gal./100	May 14,27, June 12,27 July 14,29, Aug. 8	<1	1.2	0	73
Control	unsprayed		8	50	41	

[a] Cost per acre is based on materials only at a rate of 100 gallons per acre.
[b] Disease rating made August 28 for clusters and leaves, canes were rated November 5. Values represent means of three replicate plots per treatment.
[c] Initial application was at bud break
[d] No discrimination or endorsements are implied by CSU with the material trade names used in this trial.
[e] Joy soap was added to the sunflower oil as an emulsifier.

Results:

The standard powdery mildew control program of sulfur and Nova reduced the PM incidence more and cost less per acre compared to all other treatments. The high grade paraffinic mineral oil JMS Stylet Oil, used at a concentration of 1.5% v/v, was slightly more effective at controlling cluster, leaf and cane PM incidence than either sunflower oil or M-Pede. Sunflower oil was the least effective bio-control material and M-Pede was by far the most expensive material to use. Sunflower oil was also difficult to maintain a tank emulsion even with the addition of Joy soap as an emulsifier. M-Pede produced excessive foam in the tank. JMS Stylet oil, M-Pede and sunflower oil all function as contact fungicides of PM and therefore require shorter spray intervals and more thorough coverage than with the systemic DMI Nova. Oil spray intervals of 12 -14 days appeared adequate for this trial considering the environmental conditions were optimum for PM development

This trial numerically demonstrated reduced incidence of PM infection to clusters, leaves and shoots of Chardonnay grapevines by using several bio-control materials when compared to unsprayed controls. The results of this PM trial provide us with some direction for 1998 trials which will focus on Stylet oil concentrations, sprayer application pressures and PM program combinations of Stylet oil and DMI.

CSU Viticulture Program Publications 1997-98

- 1997 Colorado Harvest Summary. March 1998. R. A. Hamman Jr., Wines and Vines 1998.

- Irrigation, a tool for Controlling Grapevine Growth and Fruit Quality. Colorado Agricultural Experiment Station Technical Report (in press). R. A. Hamman Jr. and I. E. Dami.

- The Colorado Grapevine. Technical article title Record Keeping in the Vineyard. R. Hamman, Colorado State University Cooperative Extension Fruit Growers Newsletter. Vol. 17-4, 1997.

- The Colorado Grapevine. Technical article title How to Estimate Your Grape Yields. R. Hamman, Colorado State University Cooperative Extension Fruit Growers Newsletter. Vol. 17-5, 1997.

- The Colorado Grapevine. Technical article title Powdery Mildew. R. Hamman Colorado State University Cooperative Extension Fruit Growers Newsletter. Vol. 17-6, 1997.

- The Colorado Grapevine. Technical article title Bud Break and Harvest Dates for 34 Cultivars and 4 Rootstocks and 1997 Grower Survey Results. R. Hamman Colorado State University Cooperative Extension Fruit Growers Newsletter. Vol. 18-1, 1998.

- The Colorado Grapevine. Technical article title Vineyard Growth and Fruit to wood Ratios. R. Hamman Colorado State University Cooperative Extension Fruit Growers Newsletter. Vol. 18-2, 1998.

- The Colorado Grapevine. Technical article title Grape Powdery Mildew Trials. R. Hamman Colorado State University Cooperative Extension Fruit Growers Newsletter. Vol. 18-3, 1998.

Technical Seminars

The following technical seminars were coordinated and presented by the CSU Viticulture Program for Colorado Grape Growers and the public during the period of July 1997 – June 1998:

- July 1997 – A technical paper titled Delaying Bud Break in Vitis *vinifera* C.V. Chardonnay was presented by Dr. Imed Dami (Research Assistant) at the 48th Annual Meeting of the American Society for Enology and Viticulture. He received the best student paper award at this national meeting.

- July 1997 – Participated as a wine judge at the 8th annual Colorado state Fair commercial wine competition.

- September 1997 – a seminar about the Colorado Wine Industry was presented to 75 attendees at the 6th Annual Colorado Mountain Winefest.

- November 1997 – A presentation on Grapevine Powdery Mildew and the results of the 1997 Colorado Wine Growers Survey were presented to the fall RMAVV meeting.

- January 1998 – A blind varietal wine tasting of OMRC research wines and discussion was given tot he entire staff of Grande River Vineyards.

- February 1998 – A viticulture seminar on the imposed irrigation stress study of the Canyon Wind Vineyard was presented to researchers and scientists at the annual Colorado Agricultural Experiment Station conference in Fr. Collins, CO.

- March 1998 – Two "hands on" pruning workshops for beginning and experienced growers were given to approximately 120 attendees at the OMRC test vineyard. (60 attendees at each session).

- March 1998 – coordinated activities and provided industry background information, winery tours and OMRC tour to Dr. Christian Butzke, UC Davis Cooperative Extension Enologist and guest speaker at the RMAVV spring meeting.

- April 1998 – Provided a viticulture display booth at the Farm and Ranch Days on Main Street in Grand Junction.

Research:

The CSU viticulture research program has provided and continues to provide a solid foundation of reliable support based on field trials and research activities. The research performed is of extremely high quality and is a combination of experience and collaborative interdepartmental cooperation that closely follows the overall mission and goals of the CWIDB. Below are summaries and descriptions of collaborative research projects that are either ongoing or were implemented as part of the CSU viticulture program for the 1997-98 period.

Sugar Feeding:

A Chardonnay potted vine hardiness experiment was established in 1996 at OMRC. The experiment was set up as a completely randomized block design with 3 replications per treatment. The objective of the study was to increase the cold hardiness potential of potted Chardonnay vines via solution feeding every two weeks with 0.1 molar fructose or sucrose sugar solution. In previous studies (Hamman, et. al. 1997) we found that the sugars fructose and sucrose increased in cane tissues during the onset of cold acclimation to a maximum in mid-winter and decreased as the vine deacclimated in the spring. In this study, we evaluated the cold hardiness and water content of dormant bud and cane tissues.

Root and cortical cane tissues were also analyzed for fructose and sucrose concentration using high pressure liquid chromatography (HPLC) instrumentation through the Department of Horticulture, Colorado State University. Measurements were made during December, January, February and March of 1996 - 97.

Hardiness and water content differences were not observed between treatments or control vines. Significant differences in root and cortical stem tissue concentration (fructose or sucrose) were not observed between treated and control vines. This study was well executed and analyzed. Although the results of this project were non-significant, the protocol and methodology developed will facilitate future potted vine experiments involving HPLC analysis.

Color Enhancement:

Adequate red wine color has often troubled winemakers in Colorado. Cultivars, such as Pinot noir, Cabernet franc, and Sangiovese, typically develop excellent sugar, acid and pH balances but lack desirable wine color once fermented and bottled. The purpose of this experiment is to develop a practical field method that would enhance berry skin color and thus wine color of a finished wine. Ethrel (ethephon) is a commercially available hormone that has been effective for accelerating and increasing berry color in table grapes grown in California. Previous work with table grapes has shown that ethrel should be applied near the onset of fruit softening (veraison) for optimum results.

In 1996 we conducted field trials to study the effect of ethrel treatments (500ppm) on Sangiovese and Pinto Noir. Phenolic color profile (HPLC) of Sangiovese treated and control wines was performed. Numerical differences were observed and treated vines showed 23% more total anthocyanin content. See table 1 below.

Table 1. 1996 Phenolic Color Profile (HPLC)

Sangiovese	Control	Treated (500ppm)
Caffeic Acid	21 mg/l	5 mg/l
Gallic acid	11 mg/l	11 mg/l
Polymeric Phenols	165 mg/l	161 mg/l
Total anthocyanins	85 mg/l	110 mg/l
Polymeric anthocyanins	7 mg/l	7 mg/l
Monomeric anthocyanins	78 mg/l	103 mg/l

Growth and fruit compositions were measured. Sangiovese cluster weights, total fruit weight per vine, sugar, acid and pH were measured for treated and control vines. See table 2. Significant differences were not observed between treated and control for any of the growth or fruit compositions. These non-significant differences were anticipated.

Table 2. Sangiovese Ethrel Trials

Growth and Fruit compositions

Harvest 10-16-97

Treatment	Fruit Weight/vine (Lbs.)	Cluster Weight Average (Oz.)	Brix	TA (g/l)	pH
Control	15.1	8.4	24.3	7.7	3.27
500 ppm	16.6	10.7	24.3	6.5	3.30

In 1997 field trials to study the concentration effect of ethrel on Sangiovese vines were conducted. This experiment was set up as a completely randomized design with 4 replications per treatment. All Sangiovese vines were shoot and cluster thinned in June. The vines averaged 24.8 shoots per vine and 29.3 clusters per vine. Ethrel concentrations of O, 500 ppm and 1000 ppm were applied with a hand sprayer on August 15 (veraison) when approximately 13% of the berries had changed color. The entire vine canopy was thoroughly sprayed (clusters, leaves and shoots) until a complete runoff. Growth and fruit composition was collected at harvest see table 3.

Table 3. Sangiovese Ethrel Trials

Growth and Fruit compositions

Harvest 10-16-97

Treatment	Fruit Weight/vine (Lbs.)	Cluster Weight Average (Oz.)	Brix	TA (g/l)	pH
Control	16.3[a]	5.8[a]	21.6[a]	7.8[a]	3.2[a]
500 ppm	17.6[a]	7.2[a]	20.6[a]	7.7[a]	4.2[a]
1000 ppm	17.7[a]	6.1[a]	19.3[a]	7.4[a]	3.3[a]

[a] Common letters among means within columns denote no significant difference at P<5% using Tukeys multiple comparison test.

Wines were made from each treatment and aged in glass carboys without oak additions. The wines were sulphited and racked 3 times. Color analysis was made with a Beckman 640 DV-UV visible spectrophotometer. Measurements were made before fining and filtration.

Results of Wine Color Measurements are Shown in Table 4.

Table 4. 1997 Sangiovese Ethrel Trial - Wine Color Profile					
Treatment	Color Density	Total mg/l Anthocyanins	Absorbance 520 nm	Absorbance 420 nm	Free SO_2 mg/l
#1 Control No Ethephon	1.79[a]	40.5[a]	0.822[a]	0.973[a]	4.8[a]
#2 500 ppm Ethephon	1..58[b]	39.9[a]	0.713[a]	0.862[a]	5.7[a]
#3 1000 ppm Ethephon	1.55[b]	37.2[a]	0.660[b]	0.891[b]	6.1[a]

Common letters among means within columns denote no significant difference at P<.05 using Tukey's multiple comparison test.

Color density, total anthocyanins, free, SO_2, and absorbance at the 420 and 520 nm wavelengths were measured using spectral evaluation methods developed by T. Somers and M. Evans 1976. The results of the color profile were opposite of what we anticipated. Control wine (no ethephon) was significantly darker in color that either treatment 2 (500 ppm) or treatment 3 (1000 ppm). This result was rather surprising because at harvest field observations showed earlier color development of clusters and visibly darker berries. One explanation for the puzzling results is that free SO_2 levels were much higher in treatment 2 and treatment 3 and could have "bleached out" and masked wine color density.

The methodology and protocol for spectral wine color evaluation was developed with this Sangiovese trial. Field trials this season will involve ethrel application timing as well as the efficacy of single applications on Sangiovese vines.

Cold Maceration Trials

Wine color enhancement using cold maceration techniques was also investigated in 1997. Pinot Noir (clone, 374) was harvested, crushed, and divided into 2 equal volumne wine lots. One lot was sulphited with 50 ppm with Potassium Metabisulphite, covered and stored at 40F for 6 days in a refrigerated cooler. The other wine lot (room temperature) was inoculated with "pasteur red" yeast and fermentation was immediately initiated and normal fermentation procedures were carried out. The cooler treated must was removed from the cooler after 6 days, warmed to room temperature and then inoculated with "pasteur red" yeast. Normal fermentation procedures were carried out from that point on. The results of the cold macerated Pinot Noir is provided in Table 5.

Table 5.

Pinot Noir Trial 1997					
Treatment	Color density	Total (mg/l) Anthocyanins	Absorbance 520 nm	Absorbance 420 nm	Free SO_2 mg/l
Cooler	2.32[a]	94.8[a]	1.15[a]	1.17[a]	3.83[a]
Room Temp.	1.80[b]	84.2[b]	0.79[b]	1.01[b]	8.86[b]

Common letters among means within columns denote no significant difference at P<.05 using the unpaired t test.

The "cooler" wine lot when observed with the unaided eye was noticeably darker than the

room temperature wine lot. Significant numerical differences were also found with the "cooler" treatment having more color density and total anthocyanin content. Color density is calculated by adding the 420 nm to the 520 nm measurements. Free SO_2 measurements were significantly higher in the room temperature wine lot and may have had a negative affect on color density and total anthocyanin contents.

Cold maceration for color enhancement is a common practice in may countries. This initial trial under Colorado conditions provides supporting evidence that color enhancement is possible with this technique. A repeated trial with Pinot noir is planned for this season. Future trials are needed and may provide simple, inexpensive color enhancement techniques for Colorado wine makers.

Mechanized Pruning Trial:

Mechanized pruning trials were established in 1996 and continue to date. Mechanized pruning and pre-pruning are cultural management techniques that are common in many grape growing regions of the world. Reducing labor costs while maintaining fruit quality are major reasons for this study. In this study, we used a tractor mounted "over the row" hydraulic operated pre-pruner that cut vertically positioned canes to approximately 10 inches in height. Growth and fruit compositions were measured for each treatment in this study, see Tables 5 and 6. Growth composition consisted of the following measurements: yield, cluster weight, shoots per vine, clusters per vine, pruning weight per vine and pruning weight per foot of trellis, fruit weight per vine and pruning weight per foot of trellis, fruit weight per vine and the fruit to wood ratio. Juice compositions consisted of sugar (brix), total acid (TA) and pH measurements at harvest. The initial trial in 1996 produced some interesting results with Chardonnay. Pre-pruned Chardonnay vines produced nearly double the yields 10.4 tons/acre vs. 6.1 tons/acre control without sacrificing fruit quality. In 1997, production differences were not as great between treatments but the mechanized pre-pruned vines still produced 25% more yield over control vines while maintaining excellent fruit quality.

Table 5. Mechanized Pruning Trials

Growth Composition								
Pruning Treatment	Yield (TA)	Cluster Wt. (Oz.)	Shoots/ vine	Clusters/ vine	Pruning Wt./vine	Pruning Wt./foot	Fruit Wt./Vine	Fruit:Wood Ratio
Normal 1997	5.7	4.5	25.0	45.0	1.7	0.3	13.0	7.5
Normal 1996	6.1	4.8	25.0	45.0	1.73	0.34	13.5	7.8
Mechanized 1997	7.1	3.7	42.0	78.0	1.1	0.2	16.3	14.8
Mechanized 1996	10.4	3.6	42.0	91.0	1.38	0.27	20.5	14.8

Table 6.

Juice Composition			
Treatment	Brix	TA	pH
Normal 1997	25.6	6.8	3.47
Normal 1996	24.6	7.3	3.45
Mechanized 1997	24.1	6.7	3.48
Mechanized 1996	21.6	8.7	3.32

We anticipate the mechanized pre-pruned vines to normalize growth habits over a three-year period and the 1997 data support this theory. Pre-pruned vines produced smaller clusters but more of them per vine and more shoots per vine than control vines. Pruning weights per vine were lower with pre-pruned because of the high cluster number and fruit weight and resulted in an out of balance over cropped vine. 1996 and 1997 fruit to wood ratios were very similar even though yields were lower in 1997. This is expected and is likely a result of the pre-pruned vines ability to adapt to this pruning regime.

This study has provided insight to the consequences of mechanized pruning under Colorado conditions. Future trials will help us better understand the long term effects of mechanized pruning in Colorado.

Herbicide Trials:

A pre-emergent herbicide trial was established on 12 year old Vitis *vinifera* vines in the fall of 1997. Treatments and rate/acre were as follows: T-1 Karmex at 4 pounds/acre, T-2 Goal 1.6# at 8 pints/acre, T-3 Goal 1.6E at 8 pints/acre plus Roundup at 8 pints/acre and control T-4. Threatments were applied on October 30, 1997 with a hand sprayer at the equivalent of 50 gal/acre. A four foot wide band under the vine row was treated. Visual observation of percent weed coverage was the method of treatment assessment. Visual observations fir weed establishment (See Table 7.) were made on April 9 and again on May 18, 1998. Purple top and yellow top mustard, Kochia, foxtail and field bindweed were the majority of weeds observed in this trial.

Table 7. 1997 Winegrape Pre-emergent Herbicide Trial.

Treatment	Rate/Acre at 50 gal.	% Annual Weeds[1]		% Bindweed[2]	
		April	May	April	May
T-1 Diuron (Karmex)	4 Lbs.	0	0	2	80
T-2 Goal 1.6E	8 Pints	0	0	1	80
T-3 Goal & Roundup	8 pints + 8 pints	0	0	0	55
T-4 Control (No spray)	0	50	100	15	100

1 % of Total treated area established with all annual weeds. Data are Average of 3 replications. Applied on October 30, 1997.
2 % Bindweed coverage.

The results of this trial indicate visual differences of annual weed control with all treatments. Control plots had at least 50% more annual weed development that all other treatments in April. By May the effect of annual weed control was holding in all treatments. Treatment 3 (Goal + Roundup) was providing the best overall effect, including bindweed control.

This herbicide trial demonstrates the effectiveness of Karmex, Goal and Goal plus Roundup herbicides on annual weed control in established vineyards in Western Colorado. All treatments were effective against annual weeds for at least 2 months. The tank mix of Goal plus Roundup was overall the most effective on annual and field bindweed. These herbicides could be an effective alternative tool for vineyard managers looking for methods to reduce weed control labor costs.

Irrigation, a tool for controlling grapevine growth and fruit quality

R. A. Hamman, Jr.[1] and I. E. Dami[2]

Introduction:

Commercial winegrape production in Colorado is mainly located on the Western Slope in Mesa and Delta counties (1, 3). These areas can be described as semiarid desert-like regions where total annual rainfall is very low and typically ranges between 6 and 15 inches. Therefore, irrigation is necessary for quality fruit production. Summers are normally hot with cumulative growing degree days (April 1 - Oct. 31, 50°F base) averaging 3,328 at Orchard Mesa Research Center in Mesa County (3). The climate is dry with relative humidity ranging between 20 and 60%. Soils vary widely in these areas and may consist of well drained shallow sandy soils to deeper clay loams that retain moisture. Winegrape yield and quality are determined by climate, soil, and cultural management practices including irrigation. Poor irrigation management can result in a water stressed or over vigorous condition resulting in unbalanced growth, reduced yields and inferior fruit quality (4, 7).

Grapevine water stress can occur if the supply of water to the roots is less than the evaporative demand. The cause for the stress may be low available soil moisture, high evaporative demand conditions, unbalanced shoot/root systems, a poorly developed root system, high salt levels or a combination of these (5, 6). Unlike tomatoes or squash, immediate signs of current season water stress are not clearly visible with grapevines. Symptoms are typically observed after repeated episodes of water stress which cause reduced shoot and fruit development (4, 5, 6, 7).

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Water stress symptoms can affect grapevine development in other ways as well. Water stress at bud break can result in uneven or stunted shoot growth. Under severe conditions nutritional deficiencies can flare up. Poor flower development can occur from water stressed vines and under severe conditions, flower abortion and cluster abscission may occur (5, 8). The following season's crop potential may be reduced if the vines are stressed 2 weeks prior to full bloom when cluster initiation begins (4). Immediately after fruit set, cell division and early cell enlargement occur and if the vine is water stressed, potential berry size at harvest will be reduced and thus reduced yields. Water stress between veraison and harvest can result in rapid senescence and leaf abscission and eventual loss of canopy and fruit sunburning (8). High levels of stress during this period will result in an abscission of shoot tips. Lateral shoot growth and reduced vine acclimation can occur from over irrigating following a water-stressed episode. Under these conditions, a delay in fruit maturation could occur and if exposed to extreme low temperatures, bud, cane and trunk survival could be reduced.

It is well documented that grapevines will grow excessively if provided with an abundance of water and fertilizer(4). Excessive shoot growth can have negative effects on the vine and has been associated with poor fruit set, poor fruit bud initiation for the following season, increased powdery mildew pressure, a better habitat for insects and lower fruit quality (6). Excessive shoot growth requires more cultural management input, i.e., hedging, leaf pulling, shoot thinning to produce quality fruit. It is now recognized by growers and vintners worldwide that in regions with little or no rainfall during the growing season careful vineyard irrigation strategies can be used as a tool to control grapevine canopy growth and fruit quality characteristics.

Objectives and Goals:

The following experiment was designed to evaluate current drip irrigation practices at the Canyon Wind Vineyard. Excessive growth, reduced fruit quality and excessive irrigation were concerns in this "Cabernet Sauvignon" vineyard. "Cabernet Sauvignon" is a variety characterized by its excessive vigor, which could be controlled by irrigation management and/or canopy division. If vine growth could not be reduced with irrigation management then the expensive alternative of complete

trellis modification to a divided canopy would be needed. The goal of this research project was to provide the grower with some irrigation management strategies that would help determine whether the canopy could be managed and good fruit quality maintained with irrigation techniques. The specific objectives of this experiment were to evaluate the effects of different irrigation rates on shoot length, yield components, and fruit and wine compositions. Also during the dormant season, the effect on bud and cane cold hardiness, water content, and soluble sugar content were compared between irrigation treatments. This research project was conducted during the 1997 growing season.

Materials and Methods:

Irrigation treatments and soil moisture measurements:

The seven year old "Cabernet Sauvignon" vines used in this experiment are self-rooted, bilaterally cordon pruned and trained to a six-wire vertical position trellis. The vineyard has a vine density of 968 vines per acre based on 5 ft. by 9 ft. spacing. The soil is sandy loam (60% sand, 22% silt, 18% clay) with a pH of 8.1 and an organic matter content of 2%. A soil analysis showed the nutrient level was not deficient and safe soluble salt levels of 0.30 mmhos/cm would not hinder vine growth. The soil drains very well and contains no hardpans within a 48-inch depth. Neutron probe access holes, approximately 48 inches deep, were drilled under each vine row and within 12 vertical inches from an emitter. One and a half inch diameter PVC pipe with a length of 45 inches was securely placed in each drilled hole. Each PVC was plugged with a rubber stopper and covered with a plastic cap to prevent rainfall or irrigation moisture from entering. The PVC pipe access tubes allowed for repeated, undisturbed soil moisture measurements. Each treatment had 3 neutron probe access tubes. Three soil moisture measurements per tube per date were recorded. The measurements were made with a neutron probe (Model CPN 503 DR1.5 hydropobe) at 1, 2, and 3 foot depths every two weeks beginning on 5 May until harvest on 7 October.

The experimental design was a randomized block consisting of 3 irrigation treatments and replications. Each replicate (row) consisted of 53 to 62 vines per row. Each treatment was an irrigation rate expressed in gallons per vine per week. Treatment 1 (T-1), 51 gallons (192 liters) per

vine per week was the control. Treatment 2 (T-2) was half of T-1, 25 gallons (96 liters) per vine per week. Treatment 3 (T-3), the lowest rate was 13 gallons (48 liters) per vine per week. The vineyard drip irrigation system is a pressurized, filtered system with 2 four-liter/hour emitters per vine and was used to supply each replicated treatment independently. One pressurized delivery pipe supplies water to this zone of the vineyard and therefore modifications for individual treatment control were needed. The emitter flow rate was verified for each row. The irrigation system was modified with manual valves installed at the head of each row. Depending on the treatment, the valves were manipulated during each irrigation for volume output control. Volume per irrigation was controlled by manually shutting off the valve after the desired running time was completed. For example, valves for treatment 3 would be closed after the desired level was achieved and treatment 2 would remain open for a longer designated time before closing and thus treatment 1 would receive an even longer designated run time. This manual irrigation schedule was employed 3 times per week. Treatment 1 received 8 hours of run time per irrigation which was equivalent to 16.9 gallons (64 liters) of water applied. Treatment 2 received 4 hours of run time per irrigation which was equivalent to 8.4 gallons (32 liters) and treatment 3 received 2 hours of run time per irrigation which was equivalent to 4.2 gallons (16 liters) of applied water. In order to allow timely shoot maturity and fruit ripening, all treatments were subject to 25% irrigation reduction on 11 August (veraison) through 10 October (harvest).

All standard vineyard cultural practices but hedging were employed. The treated vines were not hedged for measurement purposes of shoot length and pruning weight. Weeds were mechanically controlled. The vines were fertilized with 30 pounds of Nitrogen per acre (four 7.5-pound applications) and netting for protection against birds was applied the second week in August during verasion. Powdery mildew was controlled and no infection was observed in any treatment.

Growth Characteristics and Yield Components:

Maximum shoot length, cluster weight and berry weight were measured on 2 dates corresponding to different developmental stages. At harvest, yield components including cluster weight, berry weight and yields were determined. Pruning weights were also taken on 30 December to determine

the crop load of each treatment. The crop load is the ratio of fruit weight to pruning weight. Juice composition measurements at harvest consisted of sugar (°Brix), pH, and titratable acid content (TA, in g/l). Measurements of wine composition occurred in January after the wine was stabilized but before any fining or oak additions. The measurements were TA, pH and wine color. Color analysis was made with a Beckman 640 DV-UV visible spectrophotometer. Color density and absorbance at the 420 and 520 nm wavelengths were measured using spectral evaluation methods developed by T. Somers and M. Evans (11).

Cold Hardiness:

Cane and bud cold hardiness was measured during the dormant season in November, December and January. On each date, dormant bud and cane tissues were collected and placed in plastic bags. Samples were subjected to gradual freezing by lowering the temperature 4°C/hr. in a Tenney Jr. programable freezer (Tenney Engineering Inc., South Brunswick, N.J.). Each treatment sample was removed at 2°C intervals, for each of four stress temperatures chosen to span the probable lethal temperature on a particular sampling date. The bud and cane samples were then thawed, excised and examined for browning (10). The temperature corresponding to 50% survival (T50) was determined using the Spearman and Karber method (9).

Water Content:

Bud and cane tissues were also measured for water content. Fresh weights of the sectioned buds and canes (20 mm in length) were measured independently within four hours of collection. The tissues were dried at 70°C for seven days and dry weights were taken. Moisture content was calculated and expressed on a fresh weight basis.

Soluble Carbohydrates in Cane Cortical Tissues:

The relationship between treatments and soluble sugar accumulation in cane cortical tissues was examined. It was hypothesized that reduced irrigation levels may alter the vine's capacity to produce

high levels of soluble sugars and thus reduce its cold hardiness. Cane cortical tissue from each treatment was prepared and analyzed, as described by Hamman et al. (2) using a Dionex DX-300 series HPLC system (Dionex Co., Sunnyvale, CA). Five soluble sugars (fructose, glucose, sucrose, raffinose, and stachyose) were quantified and their respective concentrations were expressed on a mole per gram of dry weight basis.

Statistical Analyses:

Analysis of variance was performed on each experiment and treatments were compared using Tukeys multiple comparison test.

Results and Discussion:

Soil Moisture:

The first soil moisture measurements were taken on 5 May 1997, one day prior to irrigation practice. This period corresponded to bud break stage of "Cabernet Sauvignon". At the beginning of the experiment, all treatments had the same soil moistures (Table 1, Figure 1). However, subsequent moisture readings indicated significant differences among treatments throughout the season. Treatment 1, with the highest irrigation rate had the highest soil moisture. Treatment 3, with the lowest irrigation rate had the lowest soil moisture. Treatment 2 was intermediate (Table 1, Figure 1). The peaks observed in Figure 1 correspond to higher soil moisture resulting from rainfall during summer thunderstorms. Although irrigation rates were reduced by 25% on 11 August, soil moistures peaked in Mid-September as a result of an unusual and significant rainfall (over 3" in a short time period). In general, the soil moisture profile closely followed a pattern that we expected as a result of the imposed irrigation treatments.

Table 1. Soil moisture readings[1] (inches/foot) of the irrigation treatments at different phenological stages of "Cabernet Sauvignon" grown at the Canyon Wind Vineyard.

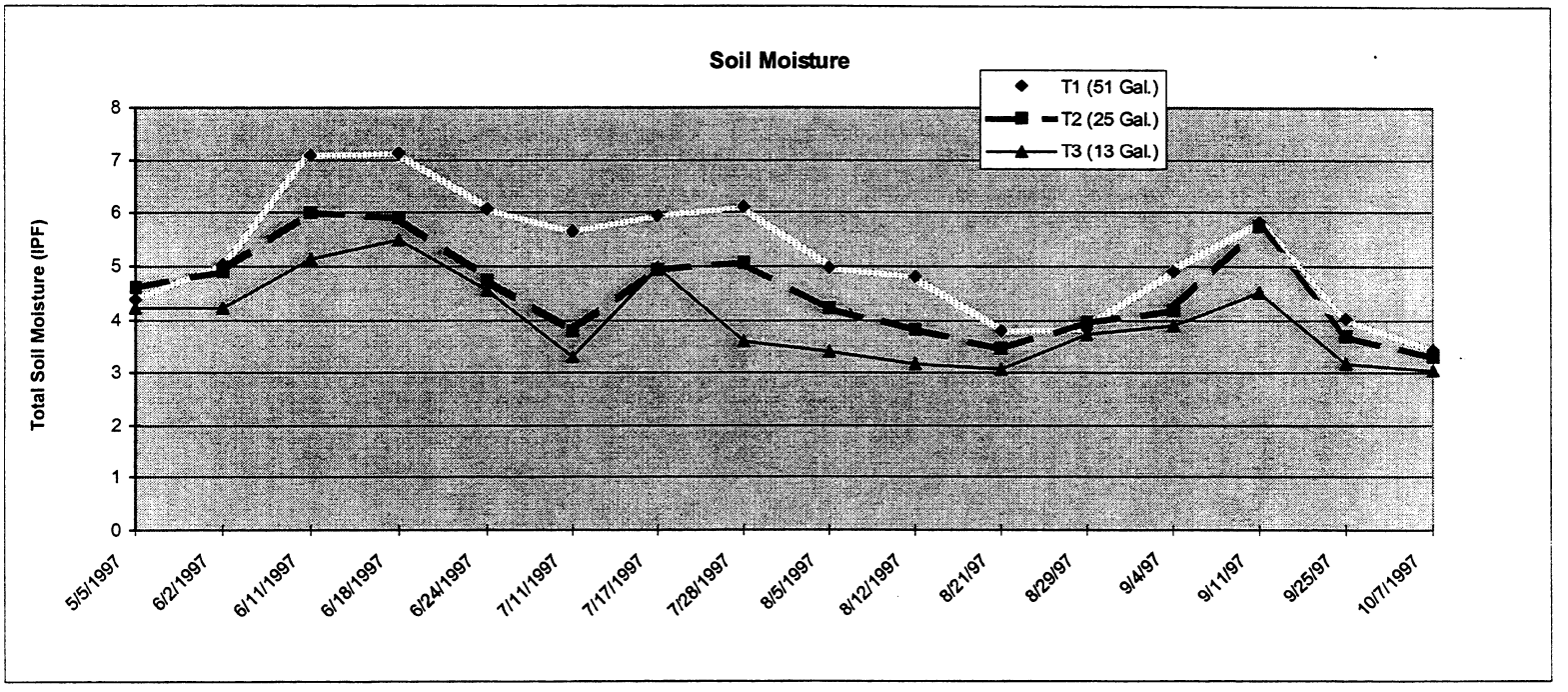
Treatment[2]	Bud Break 5/5	Bloom 6/11	1 month after bloom 7/11	Veraison 8/12	Harvest 10/7
T-1	4.4a	7.0b	5.7c	4.8b	3.4a
T-2	4.6a	5.9a	3.8b	3.8a	3.3a
T-3	4.2a	5.1a	3.3a	3.2a	3.0a

[1] Measurements represent the total moisture for the top 3 feet of soil.

[2] T-1=51 gallons per vine per week, T-2=25 gallons per vine per week, T-3=13 gallons per vine per week. Irrigation started on 6 May 1997. All rates were reduced by 25% on 11 August through 10 October.

Common letters among means within columns denote no significant difference at P<5% using Tukeys multiple comparison test.

Fig. 1. Soil moisture profile of 3s irrigation treatments imposed on "Cabernet Sauvignon" vines grown at the Canyon Wind Vineyard. Measurements represent the total moisture for the top 3 feet of soil.



Shoot and Fruit Growth Characteristics:

Canopy size differences among treatments were visible by bloom stage (11 June). Treatment 3, with the lowest rate had the shortest canopy height as compared to T-1 and T-2 (data not shown). Measurements, however, were not taken until one month after bloom, and at veraison (Table 2). On both dates, irrigation treatments had drastic effects on shoot and fruit growth. Lower rates in T-2 and T-3 resulted in shorter shoots and smaller fruit than those of the highest rate in T-1 (Table 2). It is concluded that the reduction in shoot and fruit growth in T-2 and T-3 is a response to water stress imposed by irrigation deficit treatments. These results agree with previous studies (5, 6) although visible differences occurred earlier than anticipated. Previous work by Wample (6) has shown that visible differences would not show until after full bloom, but this was not true in this study.

Table 2. The effect of irrigation treatments on growth characteristics of "Cabernet Sauvignon" at different phenological stages.

Date	Phenological Stage	Treatment	Shoot length (inches)	Cluster weight (g)	Berry Weight (g)
11 July	One month after bloom	T-1=51 gal.	79b	95b	17c
		T-2=25 gal.	59a	67ab	10b
		T-3=13 gal.	52a	46a	7a
12 August	Veraison	T-1=51 gal.	104b	107a	20b
		T-2=25 gal.	74a	100a	17a
		T-3=13 gal.	63a	91a	16a

Common letters among means within columns denote no significant difference at P<5% using Tukeys multiple comparison test.

Yield components:

Cluster weight of T-1 was the highest, but not significantly different from T-2 (Table 3). Treatment 3 had the lowest cluster weight. Similar results were observed with berry weights (Table 3). The fruit weight per vine was the lowest in T-3 at 8 lbs./vine, which corresponds to an estimated yield of 3.8 Tons/acre (Table 3). Treatment 2 averaged a higher cluster weight/vine than T-1, but the difference was not significant; consequently the yields were equivalent (5.6 Tons/acre in T-2 vs. 5.2 Tons/acre in T-1) (Table 3). It is evident that the lowest irrigation rate (T-3) negatively affected the yield. Treatment 2 produced a similar yield to T-1, although it received half the amount of water. This may suggest that with a moderate irrigation deficit, yields are not affected. It should be noted, however, that soil moisture of T-2 were as high as T-1, about 10 days after veraison through harvest (Figure 1). This extra moisture (probably from rainfall) may have contributed to the slight increase in fruit weight/vine, and resulted in similar yields between T-1 and T-2.

Pruning weight, crop load and vine balance:

The highest irrigation treatment (T-1) had the greatest pruning weights at 2.3 lbs./vine, followed by T-2 and T-3 at 1.5 and 1.2 Lbs./vine, respectively (Table 3). Well balanced vines should have pruning weights ranging from 0.2 to 0.4 Lbs./foot of row (8). Vines from T-1 had 0.5 Lbs./ft, which indicates a high-vigor situation. Visual observation of these vines during the growing season confirmed these results, and showed excessive canopy density. This particular situation may create shading problems and produce low fruit quality; thus vines of T-1 are considered to be out-of-balance. Crop load is another way to quantify whether there is a balance between vegetative growth and crop yield. Research and practical experience have shown that crop load below 5 (4.5 in T-1) indicate excessive vegetative growth in relation to crop weight. It is concluded that due to excessive canopy vigor, the irrigation rate in T-1 is too high at 51 gal./vine/week, especially early in the season.

Treatment 2 had 0.3 Lbs. of pruning weight per foot of row. This value is within the optimum range and thus vines from T-2 are considered to be well-balanced. The crop load value of 7.6 is also within the optimum range. This indicates a good balance between the canopy size and the crop that it supports. It is concluded that the irrigation treatment at 25 gal/vine/week provided

the best balanced vines with optimum fruit to wood ratio. Treatment 3 at 0.2 Lbs./ft. of row had the lowest prunings, yet within the acceptable range. The crop load at 6.5 was also within the acceptable range. Although these numbers lead to the conclusion of somewhat balanced vines, other considerations should be taken into account. In fact, field observations have indicated that these vines were severely water stressed to the extent that fruit shriveled during the ripening stage in mid-August. Therefore, the irrigation rate at 13 gal/vine/week is not recommended under these conditions.

Table 3. Irrigation effects on yield components, pruning weights and crop load of "Cabernet Sauvignon".

Treatment	Cluster Wt. (g)	Berry Wt. (g)	Fruit Wt. Per vine (lbs.)	Tons/Acre	Pruning wt/Vine (Lbs.)	Pruning wt./foot of row (lbs/ft)	Crop Load Yield/Pruning
T-1	136b	29c	10.7ab	5.2	2.3b	.5	4.5a
T-2	109ab	23b	11.5b	5.6	1.5a	.3	7.6b
T-3	83a	17a	8.0a	3.8	1.2a	.2	6.5ab

Common letters among means within columns denote no significant difference at P<5% using Tukeys multiple comparison test.

Juice Compositions:

Juice compositions at harvest were analyzed and differences were observed. To facilitate Canyon Wind's harvest operations, all treatments were harvested 10 days earlier than anticipated. Although fruit maturity levels indicate slightly underripe fruit, juice composition levels were showing significant differences among treatments (Table 4). Significant differences in Brix and juice pH's were observed. Titratable acidities at harvest were similar among treatments. Previous studies (6) have shown that late season irrigation deficits to slightly increase sugar (Brix) levels at harvest which was not observed in this study. Treatment 3 sugar levels of 20.2 were significantly lower than either T-1 or T-2. It is likely the vines from T-3 underwent severe water stress that caused a physiological adjustment which resulted in stomal closure. This led to reduced photosynthesis and thus decreased levels of soluble sugars.

Table 4. Irrigation effects on 1997 "Cabernet Sauvignon" harvest juice composition.

Treatment	Brix	pH	TA
T-1	22.3b	3.02ab	8.6a
T-2	21.7b	2.99a	8.9a
T-3	20.2a	3.08b	7.4a

Common letters among means within columns denote no significant difference at P<5% using Tukeys multiple comparison test.

Wine Composition and Color:

Wines were made from each treatment and aged in glass carboys without oak additon. The wines were sulphited and racked 3 times. The wines were analyzed for TA, pH and wine color (Table 5). The irrigation treatments influenced wine TA,pH, color density and color absorbance at industry standards of 420 and 520 nm wavelenths with T-3 having the darkest (highest absorbance) colored wine. This color enhancement observed in T-3 from a winemakers view was a positive effect byt should not be the only consideration to vineyard irrigaton strategies.

Table 5. Irrigation effects on 1997 "Cabernet Sauvignon" wine composition[1] and wine color[2].

Treatment	TA	pH	Color Density	Absorbance 520nm	Absorbance 420nm
T-1	7.0a	3.53b	6.41a	3.74a	2.67a
T-2	7.1a	3.49b	7.41b	4.37b	3.04b
T-3	7.9b	3.43a	8.70c	5.21c	3.50c

1. Wine lots not replicated

2. Color is based on light absorbance at the 420 and 520 nanometer wavelengths.

Common letters among means within columns denote no significant difference at P<5% using Tukeys multiple comparison test.

Cold Hardiness and Water Content:

Bud and cane tissues for each treatment were subjected to freezing tests and analyzed for water content on three dates, 3 November, 1997, 3 December 1997, and 9 January 1998. Differences among irrigation treatments in cold hardiness and water content of bud and cane tissues were not observed on any of the three sampling dates. Only data of November sampling are shown in Table 6. It is concluded that with these irrigation treatments, cold hardiness of buds and canes is not negatively affected. A previous study by Wample (1997) found similar results.

Table 6. Irrigation effects on "Cabernet Sauvignon" cold hardiness (T50)* and water content (WC) measured on 3 November 1997.

Treatment	T50 Bud (°C)	T50 Cane (°C)	WC-Bud (%)	WC-Cane (%)
T-1	-18.3a	-18.1a	29.9a	42.0a
T-2	-17.1a	-17.3a	27.9a	42.2a
T-3	-17.7a	-17.8a	27.6a	42.5a

*T50 is the lowest temperature at which 50% of the population survives.

Common letters among means within columns denote no significant difference at P<5% using Tukeys multiple comparison test.

Soluble Carbohydrates in Cane Cortical Tissues:

The accumulation of the soluble sugars (glucose, fructose, sucrose, raffinose and stacyhose) in the internode stem tissue was measured and analyzed (Table 6) for treatment differences over the same sampling dates as above. Significant differences between treatments were not observed for any of the sugars analyzed on each date. However, the concentration of each sugar increased from November to January with all treatments (Table 7). This accumulation of soluble sugars during the mid-winter season is not a response to irrigation treatments, but a physiological response to low temperature as concluded by Hamman et al. (2). Since irrigation treatments did not affect cold hardiness it is unlikely that they would affect carbohydrate accumulation.

Table 7. Irrigation effects on soluble sugar (10^{-5} moles/gram of dry weight) in "Cabernet Sauvignon" internode tissues from 1 November 1997 to 1 January 1998. On each sampling date, no significant differences were observed between the three treatments for each sugar compared. Data are based on means of three replicates for each collection date.

	November			December			January		
	T-1	T-2	T-3	T-1	T-2	T-3	T-1	T-2	T-3
Glucose	4.8	4.8	5.5	10.0	10.7	9.5	15.6	12.9	13.9
Fructose	2.0	1.4	2.2	6.2	7.6	6.9	13.2	12.4	10.9
Sucrose	4.2	3.9	4.1	5.9	6.4	6.6	10.9	10.0	8.6
Raffinose	4.3	3.4	3.1	1.3	1.5	1.1	2.4	1.5	1.9
Stachyose	1.2	1.1	0.9	2.7	1.9	1.9	2.4	1.5	1.4

Conclusions:

Significant findings were realized in this study. First, it is possible to control the canopy development of grapevines by irrigation management. We found that for this particular soil and site, the rate of 25 gal/vine/week imposed until veraison, then reduced by 25% through harvest, provided the best balanced vines with good canopy size, good yields, and excellent fruit and wine quality. Growers should realize that these rates may change in other sites with different soil characteristics and weather conditions. In practice, rates should be modified according to the stage of development of grapevines and their water requirements at that time of the season. Second, cold hardiness of buds and canes was not affected by the imposed irrigation deficit treatments. This implies that irrigation deficit practice could be used in Colorado vineyards for fruit quality control without compromising cold hardiness. Cold hardiness is an important factor to consider in this area due to the likelihood of winter injury. In addition, treatments with reduced irrigation had an early cane maturity (data not shown); thus less susceptibility to early fall frost. Third, carbohydrate reserves in canes were not affected by irrigation treatments. Therefore, imposing irrigation deficit would not compromise the deposition of carbohydrates which are essential for winter protection

Other advantages of reduced irrigation treatments are savings in cost of labor and materials

associated with canopy management practices such as irrigation, pesticide application , shoot and leaf removal, hedging, pruning, etc. One major advantage for this particular vineyard is the dismissal of the plan to retrofit the current training system to an expensive divided canopy system. It is concluded that given the proper irrigation, the canopy size of "Cabernet Sauvignon" can be controlled and confined to the simple vertical-shoot-position system without the need for canopy division.

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1997 Growth and Fruit Compositions of 35 Cultivars and 4 Rootstocks Grown in Western Colorado

R. A. Hamman, Jr.[1] and I. E. Dami[2]

Introduction

Wine grape performance is influenced by climatic sequences during each growing season. Evaluating the performance by measuring specific growth and fruit composition parameters of each cultivar grown in Western Colorado is extremely helpful to Colorado wine grape growers when deciding what cultivar to plant.

Interest in Western Colorado's potential to commercially produce wine grapes continues to increase. (Less than 20 acres in 1980 to over 400 acres in 1997.) New vineyards are being planted at a rate of approximately 30 acres per year. These vineyards are being planted in various locations throughout Western Colorado often where commercial grape production has never occurred. The topography of these locations varies enough to dramatically influence temperature changes and thus fruit quality and production. The following report is intended to provide growers with 1997 performance characteristics of 35 cultivars grown at the Orchard Mesa Research Center in Grand Junction, CO.

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The technical assistance of John Wilhelm, David Neil, Susan Baker and Refugio Diaz is acknowledged and appreciated.

Materials and Methods

Vineyard and weather data were recorded from test vineyards located at the Orchard Mesa Research Center (OMRC) in Grand Junction, Colorado at the elevation of 4,596 feet. Two test vineyards (vineyard A is furrow irrigated and vineyard B is drip irrigated) were used for the data presented. The soils in both vineyards are Mesa clay loams. Each cultivar of vineyard B consists of 16 vines (4 replications with 4 vines per replication) and was completely randomized. The rootstock trial was planted in 1992 and consists of a completely randomized design of 16 replications with 10 vines each. Chardonnay clone 104 was grafted to the following four rootstocks: 5C, 101-14, 420-A and 3309. All of the grapevines evaluated were between 5 - 13 years old and were spur-pruned and trained to bilateral cordons on a 6-wire vertically shoot positioned trellis system. Vineyard A has 2 vine spacings, 605 vines per acre (7 ft. between vines and 12 ft. between rows) and 726 vines per acre (6 ft. x 10 ft.). Vineyard B and the rootstock trial have a vine spacing of 871 vines per acre (5 ft. x 10 ft.).

Vineyard A was furrow irrigated 6 times the entire season, beginning May 15 and ending July 25. Each irrigation was 6 hours. Vineyard B was drip irrigated 2 times per week beginning May 8 and ending August 29 totaling 25 gallons per vine per week for a season total of 316 gallons per vine. Rainfall recorded at OMRC for the 1997 April - October period was 12.51 inches, a near record. Standard fall irrigations were not applied to either vineyard base on neutron probe soil moisture readings and the 2.7 inches of extra rainfall, well above the 30-year average precipitation level for September and October.

Standard cultural management practices were implemented including spur pruning in March, mechanical weed control (5 separate hydraulic hoe cultivations), pest and disease management control and bird control (Plastic netting was applied August 15). Powdery mildew was controlled with 7 spray applications including 4 wettable sulfur sprays and 3 spray applications of the demethylase inhibitor fungicide Nova. The powdery mildew control program began May 27 and finished August 8. Crop load and vine balance adjustments were made to all cultivars by shoot thinning the first week of June. Overcrowded and weak shoots (<10" growth)

were automatically removed and the remaining shoots were spaced to approximately 4 - 5 inches. Crop load was also adjusted by removing excess clusters July 22. Secondary cluster development and clusters on shoots with less than 15 inches of growth were removed. All vines were hedged 10" above the top trellis wire by late July. Fruit maturity parameters and harvest date were determined by sampling 50 - 100 berries per cultivar and testing for sugar (soluble solids), total acidity and pH. At harvest, a must sample was taken to determine sugar (°Brix, using Milton Roy Laboratory Refractometer), pH (Orion 720A pH meter) and titratable acidity (titration with 0.100 N Sodium Hydroxide to end point pH of 8.2). All samples were centrifuged using a table top International clinical centrifuge. At harvest average cluster, fruit, and vine weights and yield (tons per acre) were measured for each cultivar. Clusters per vine and shoots per vine were counted in August and pruning weights were measured in February and March. The fruit weight to pruning weight ratios were calculated by dividing the average fuit weight by the average pruning weight. This ratio is a good indicatoion of vineyard growth. Chardonnay for example has a ratio of 7.6:1 which indicated that for every 7.6 pounds fruit there is 1 pound of pruned wood, a well balanced vine. Years of research and practical experience have proven that optimum ratios of fruit to wood will be between 5:1 to 10:1 for a wide range of vineyard situations. Very low ratios of 1, 2 or 3:1 indicate excessive vegetation and fruit to wood ratios of 12, 15 or 20:1 indicate the vines were overcropped.

Climate Summary

Average monthly mid-winter low temperatures recorded at OMRC were 2°F to 7°F warmer than the 30-year average. A potentially devastating spring frost (17°F) occurred April 12, 1997. There was no bud or cane injury or crop reduction from this unusual spring frost. The date of bud break (stage 5 using the Eichorn Lorenz method) was normal for all cultivars presented in Table 3. Bud break began April 25 with Andover and ended May 10 with Sangiovese. Rainfall was abnormally high for this area with 12.9 inches compared to the normal 6.2 inches for May - October. The total cumulative growing degree days (April 1 - October 31, 50°F base) for 1997 was slightly warmer (3451) than the 30-year average (3328). Harvest began with Aurora, August 21 and ended with Sangiovese October 16. All cultivars were harvested later than the previous 2 years. Chardonnay was harvested October 9 which was 23 days later

than 1996 and 14 days later than 1995. One explanation for the late harvest could be evaporative cooling from unusually high rainfall during the final ripening stage (August - October). During this period, 5.92 inches of moisture was recorded which was 3.42 inches above the 30 year average. The first fall frost of 1997 occurred the morning of October 13 (26°F) and was 2 weeks earlier than normal.

Results and Discussion

The highest yielding cultivar was Flora at 9.7 tons per acre followed by Semillon at 8.3 tons per acre. The lowest yielding cultivar was Norton at 1.6 tons per acre followed by Andover at 2.3 tons per acre. Cluster weights were highest with Semillon at 12.5 ounces per cluster followed closely by Muscat blanc which averaged 11.1 ounces per cluster. See Table 1. Pruning weight per vine were quite variable and indicate genetic vigor differences between cultivars. Malbec, Shiraz and Carmine averaged over 2 pounds of pruning wood per vine and were the most vigorous in this trial. Siegerebe, Pinot gris, Dolcetto, Angover and Aurora were the least vigorous cultivars with average pruning weights of 0.6 - 0.7 pounds per vine.

Fruit weight to pruning weight ratios were acceptable (5:1 to 10:1) for all cultivars except Seigerebe, Semillon, Seyval blanc, Pinot blanc, Dolcetto and Aligote. These cultivars were over balanced and had fruit to wood ratios that ranged between 11.2 to 19.8. Ratios above 10:1 represent vines with too much fruit and very little folage. The fruit of an over balanced vine often never adequate matures and this may partially explain the poor sugar development of Seigerebe which had a fruit to wood ratio of 19.8.

At harvest juice compositions (Table 2) for all cultivars except Andover matured to acceptable ranges for wine-making purposes. The total acid (TA) for Andover was extremely high at 17.2 g/l. Seigerebe matured with the lowest sugar of 17.8° Brix. Vignole; had the highest sugar development, 30.2°Brix. The fruit of Vignole was purposely left to ripen longer to develop a higher sugar concentration for a sweet style reserve wine. Vignole retained desirable high acid (9.8 g/l) and normal pH (3.23) even at 30.2°Brix. PH measurments for all cultivars

were recorded between 3.0 - 3.68. Late maturing cultivars such as Rkatsitelli, Riesling, Norton and Sangiovese all achieved desirable juice compositions in spite of the forced harvest from the early frost of October 13.

Rootstocks:

The vines in the rootstock trial are just now becoming mature enough for data collection. The data presented in tables 3 and 4 are preliminary observations and should not be considered as recommendations. A minimum of 5 years of collected rootstock data are needed before recommendations can be made. The observations we made provide some preliminary indications of the performance of 5C, 420A, 3309 and 101-14 rootstocks grafted to Chardonnay 104 in western Colorado. Bud break for 5C occurred May 2 (Table 5) which was earlier than the self-rooted Chardonnay and all the other rootstocks. 3309 was the last to develop with it's bud break occurring May 6. The date of harvest for all four rootstocks was October 8. Cluster weight, fruit weight per vine and yield (tons per acre) were observed to be greater with 420-A than any other rootstock but similar to self-rooted Chardonnay (Table 3). The rootstocks 3309 and 101-14 had the lowest yields (4.7 tons per acre and 4.6 tons per acre respectively), cluster weights and fruit weights per vine.

The most surprising observation of all four rootstocks in 1997 was the early stunted shoot growth of 3309. On June 4 we measured 3309 shoot length at 4 - 5 inches. Shoot length of 5C planted next to and within the same row as 3309 measured 24 inches. This stunted growth was not observed with 5C, 420A or 101-14. All rootstocks were irrigated equally at a rate of 25 gallons per vine per week. This unusual stunted growth of 3309 may indicate the need for higher water requirements early in the season. However, further study is needed to support this theory. By the end of June 1998, evaluations have indicated an excessively high percentage of stunting with all four rootstocks. 3309 had 74% stunting, 420A had 66% stunted growth, 101-14 had 51% stunted growth and 5C had only 12% stunted growth. The stunted growth appears similar to that of 1997 and may be associated with low temperature injury.

Juice compositions for all 4 rootstocks (Table 4) were similar but did not show any large differences from self-rooted vines.

Conclusions

The cultural management (i.e. pruning, irrigating, weed control, disease control, shoot thinning and cluster thinning) and experimental design of this trial allowed us to make controlled accurate growth and fruit composition measurements of 35 cultivars and 4 rootstocks for he 1997 season. Based on this 1997 data, wine grape performance for all 35 cultivars and 4 rootstocks with the exception of Andover and French Columbard was excellent. Fruit quality measurements (sugar, acid and pH) were good and can be described as having excellent wine potential. The 1997 harvest was approximately two weeks later than normal, however, fruit quality was not compromised. The rootstock trial needs further study and conclusions are premature, however, the growth performance and fruit quality of 5C and 420-A for the 1997 season was good and very similar to the performance of self-rooted vines.

Table 1. 1997 Growth Compositions for 35 cultivars grown at Orchard Mesa Research Center.

Cultivar	Vine Age	Vineyard Spacing	Tons/ Acre	Cluster Wt. (oz.)	Clusters/ Vine	Shoots/ Vine	Fruit Wt./Vine (lbs)	Pruning Wt.	Fruit Wt/Pruning Wt. (ratio)
Aligote *	13	7'x12'	4.1	5.8	66.5	29.5	13.5	1.00	13.5
Andover *	8	6'x10'	2.3	3.5	36.7	17.2	6.3	0.60	9.8
Aurora *	8	6'x10'	2.6	3.5	44.0	26.7	7.2	0.70	10
Cabernet Franc *	6	6'x10'	4.0	5.1	51.8	26.8	11.0	1.20	8.8
Carmine *	13	7'x12'	7.6	5.6	81.0	37.0	25.1	3.10	7.9
Cabernet sauvignon*	5	6'x10'	5.1	5.6	53.4	31.4	14.0	1.40	9.9
Cayuga White	6	5'x10'	5.0	7.8	33.5	33.4	11.5	1.10	9.9
Chardonel	6	5'x10'	5.9	7.4	32.0	27.1	13.5	1.60	8.2
Chardonnay	6	5'x10'	5.7	4.5	45.1	25.1	13.0	1.70	7.6
Dolcetto	5	5'x10'	3.6	6.6	23.7	27.3	8.3	0.60	12.7
Flora	13	7'x12	9.7	6.9	×	×	×	×	×
French Columbard*	13	7'x12	7.6	11.0	×	×	25.1	×	×
Gamay Beaujolais*	13	7'x12	4.1	5.5	53.0	34.0	13.5	×	×
Gewurztraminer*	6	5'x10'	7.3	6.5	45.3	32.3	16.8	1.70	9.4
La Crosse*	8	6'x10'	4.5	4.6	×	×	12.3	×	×
Malbec*	13	7'x12	7.4	8.6	70.0	34.0	24.4	3.80	6.3
Merlot	6	5'x10'	6.8	8.7	34.5	29.2	15.6	1.50	10.0
Müller thurgau	6	5'x10'	4.7	7.2	28.7	20.7	10.8	1.00	10.2
Muscat Blanc *	13	7'x12	6.2	11.1	41.8	36.3	14.2	1.70	8.3
Norton	6	5'x10'	1.6	3.9	26.8	24.4	3.7	1.00	10.2
Pinot Blanc #159	6	5'x10'	5.0	8.5	30.0	26.2	11.5	0.80	13.8
Pinot Gris	6	5'x10'	2.9	4.8	28.0	23.6	6.6	0.70	9.1
Pinot Noir #347	6	5'x10'	4.6	5.6	35.2	30.5	10.5	1.00	9.9
Pinot Noir-Dijon	6	5'x10'	3.0	4.9	25.8	27.4	6.8	0.80	7.9
Riesling	6	5'x10'	4.8	5.8	37.9	25.5	11.02	2.00	5.4
Rkatsitelli *	8	6'x10'	5.3	6.9	29.1	19.8	12.2	0.90	13.1
Sangiovese	6	5'x10'	6.1	8.0	23.8	24.6	14.0	1.30	10.5
Seigerebe *	8	6'x10'	4.4	4.5	41.3	23.0	12.1	0.60	19.8
Semillon *	13	7'x12	8.3	12.5	65.2	31.2	27.4	2.40	11.20
Seyval Blanc	6	5'x10'	5.9	5.9	36.3	29.5	13.5	1.10	11.5
Shiraz	6	5'x10'	6.9	7.2	42.3	29.2	15.8	2.40	6.4
St. Pepin *	8	6'x10'	6.4	6.1	×	×	17.6	×	×
Sylvaner *	13	7'x12	6.4	5.8	74.0	40.0	17.6	×	×
Vignoles	6	5'x10'	3.0	4.2	34.2	28.0	6.9	1.10	5.8
Viognier	6	5'x10'	5.7	4.9	32.5	25.1	13.0	1.50	8.6

* Furrow irrigated, 2 - 19 vines per cultivar, planting not randomized.

Table 2. 1997 at harvest juice compositions for 35 cultivars grown at Orchard Mesa Research Center.

Cultivar	°Brix	TA (gms./l)	pH
Aligote *	24.2	6.4	3.23
Andover *	22.4	17.2	3.42
Aurora *	21.0	6.8	3.40
Cabernet Franc *	23.8	5.5	3.37
Cabernet sauvignon*	23.0	5.8	3.28
Carmine *	23.6	5.2	3.36
Cayuga White	23.0	6.2	3.36
Chardonel	23.2	10.7	3.30
Chardonnay	24.4	6.8	3.47
Dolcetto	24.0	6.4	3.36
Flora	23.6	6.5	3.37
French Columbard*	20.0	14.5	3.00
Gamay Beaujolais*	23.4	5.5	3.34
Gewurztraminer #457	23.0	6.0	3.32
La Crosse*	24.0	7.8	3.48
Malbec*	23.2	7.9	3.35
Merlot	23.2	4.3	3.45
Müller thurgau	22.8	5.6	3.45
Muscat Blanc *	22.2	5.6	3.22
Norton	25.2	6.1	3.36
Pinot Blanc #159	22.0	5.5	3.31
Pinot Gris	23.2	7.6	3.30
Pinot Noir #347	23.0	6.9	3.44
Pinot Noir-Dijon	22.8	5.1	3.43
Riesling	23.6	8.6	3.02
Rkatsitelli *	23.6	6.4	3.03
Sangiovese	21.4	7.65	3.14
Seigerebe *	17.8	4.4	3.51
Semillon *	24.0	5.0	3.26
Seyval Blanc	21.6	6.7	3.51
Shiraz	23.5	5.8	3.44
St. Pepin *	23.2	7.0	3.68
Sylvaner *	25.0	6.0	3.43
Vignoles	30.2	9.8	3.23
Viognier	24.4	6.6	3.28

* Furrow irrigated, 2 -19 vines per cultivar, planting not randomized.

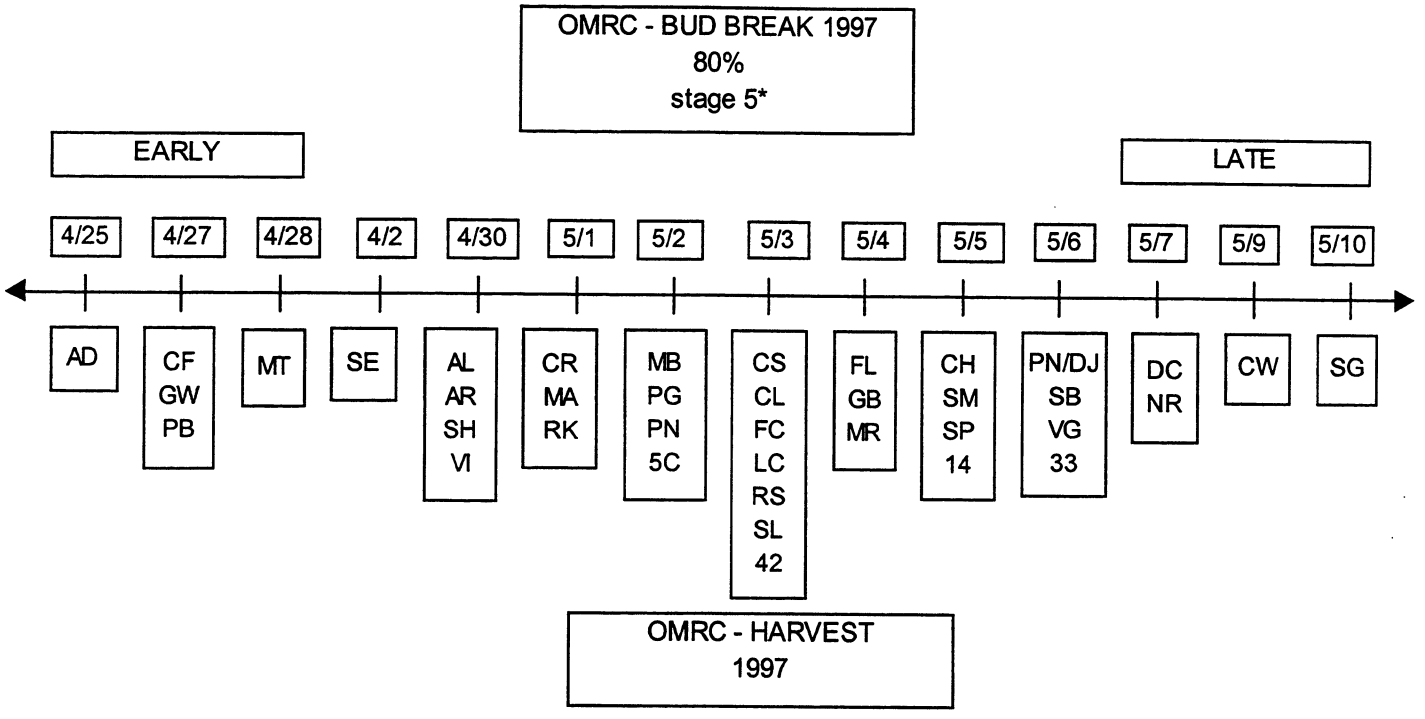
Table 3 & 4. Preliminary rootstock observations. 1997 growth and fruit compositions of Vitis *vinifera* "Chardonnay" clone 104 grafted to four rootstocks.

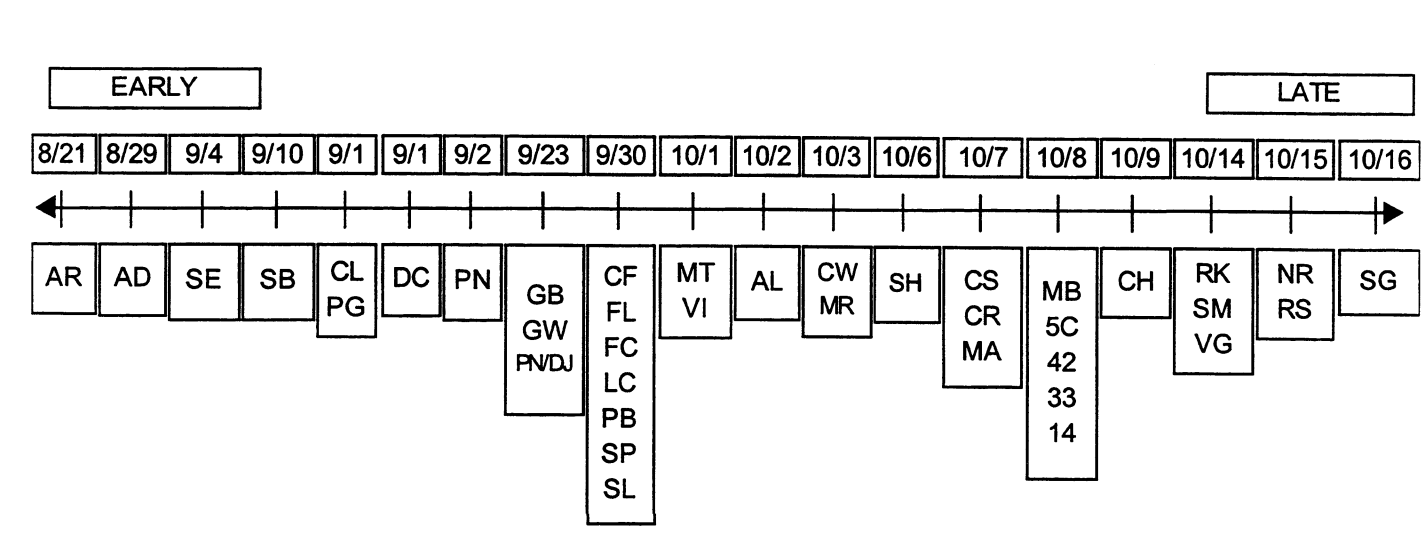
Growth Composition								
Rootstock	Vine Age	Cluster Wt. (Oz.)	Fruit Wt/Vine (Lbs.)	Tons/ Acre	Clusters/ Vine	Shoots/ Vine	#/vine Pruning Wt.	Fruit Wt./Pruning Wt. Ratio
3309	5	5.0	10.8	4.7	29.7	21.5	2.07	5.2
420-A	5	5.7	13.3	5.8	37.1	22.2	2.10	6.3
101-14	5	5.1	10.6	4.6	35.9	22.3	2.47	4.3
5C	5	5.4	11.7	5.1	32.5	20.6	2.40	4.8
Self-rooted	6	4.5	13.0	5.7	45.0	25.0	1.74	7.5

Table 4.

Juice Composition			
Rootstock	°Brix	TA	pH
3309	22.8	7.2	3.32
420-A	22.6	6.8	3.28
101-14	23.5	6.6	3.35
5C	23.3	5.8	3.36
Self-rooted	22.3	5.7	3.45

Table 5. 1997 Bud Break and Harvest dates for 35 cultivars and 4 rootstocks.





LEGEND

AL-Aligote	CH-Chardonnay-Self	MT-Muller thurgau	SG-Sangiovese	ROOTSTOCKS-grafted to Chardonnay 104
AD-Andover	DC-Dolcetto	MB-Muscat Blanc	SE-Seigerbe	
AR-Aurora	FL-Flora	NR-Norton	SM-Semillon	5C-5C
CF-Cabernet Franc	FC-French Columbard	PB-Pinot Blanc	SB-Seyval Blanc	42-420-A
CS-Cabernet Sauvignon	GB-Gamay Beaujolais	PG-Pinot Gris	SH-Shiraz	33-3309
CR-Carmine	GW-Gew urztraminer	PN-Pinot Noir	SP-St. Pepin	14-101-14
CW-Cayuga White	LC-LaCrosse	PN/DJ-Pinot Noir Dijon	SL-Sylvaner	
CL-Chardonel	MA-Malbec	RS-Riesling	VG-Vignoles	
	MR-Merlot	RK-Rkatsitelli	VI-Viognier	

*Note that the actual bud break "stage" of development was determined by using the Eichorn-Lorenz 1977 method. Stage 5 is when the emerging green shoot is first clearly visible. The actual date of bud break is when 80% of the vine reaches stage 5.

CSU-OMRC Viticulture Research

July 1997 - June 1998

Appendices

1997
*Colorado Wine Grower Survey**

Total Acres	Producing Acres	New Acres	Total Yield (Tons)	Ave. T/A
261	223	27	755	3.4

Tons sold to out-of-state markets = 114 (15%)

County	Acres (% Total)
Mesa	90
Delta	9
Other	<1

51 vineyards surveyed
Average size = 5.7 acres

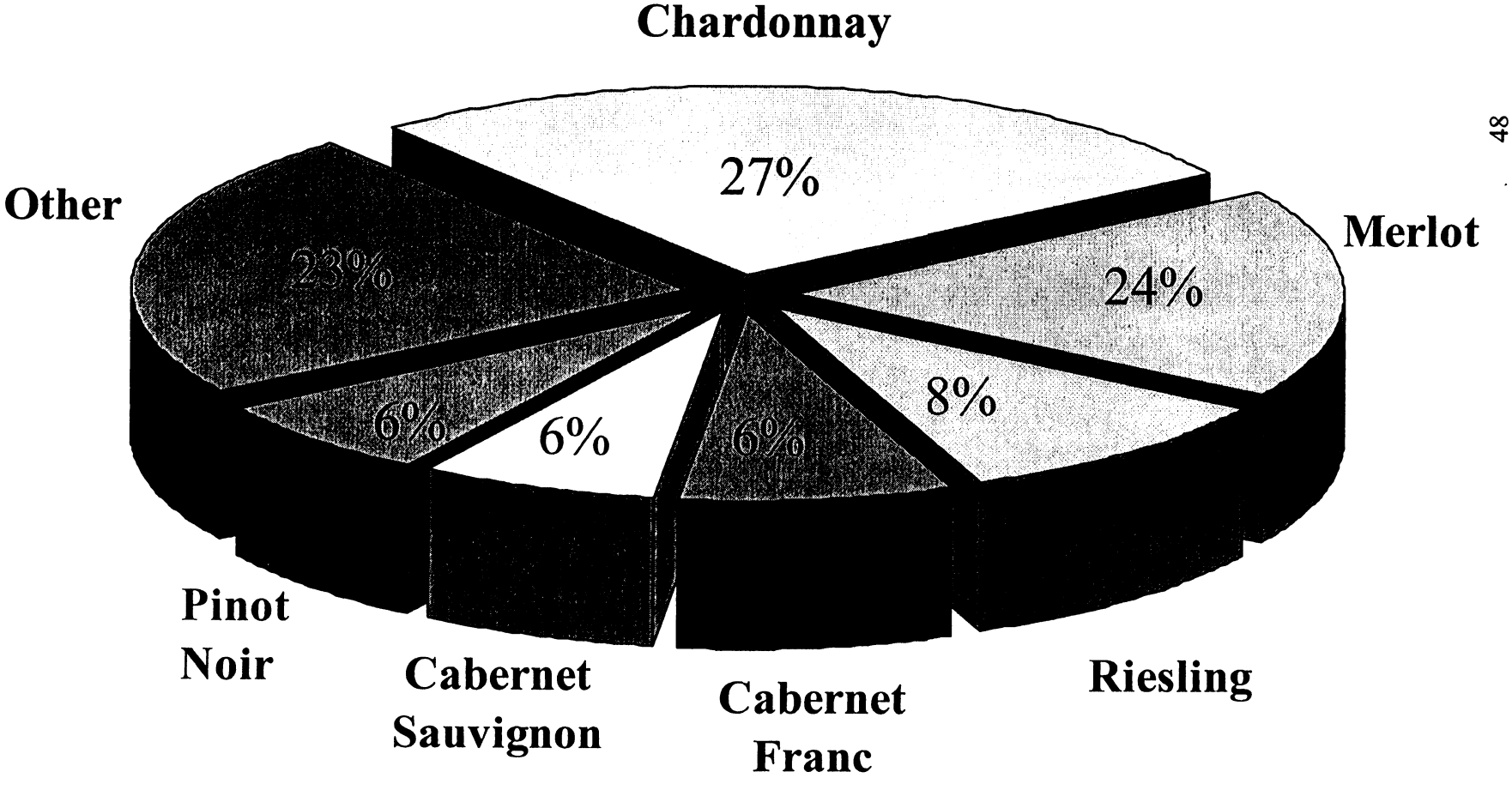
Variety	Harvest Date	% Acreage	% Yield	Ave. Yield T/A	Price ($/T)
Chardonnay	9/4-10/20	27	23	2.6 (1-10)	1194 (800-1400)
Merlot	9/9-10/14	24	25	3.9 (1-7)	1293 (1100-1500)
Riesling	10/3-16	8	8	3.6 (1-11)	800 (700-940)
Cabernet Franc	9/16-10/14	6	6	5.2 (4-7)	1387 (1300-1450)
Cabernet Sauvignon	9/20-10/18	6	7	4.2 (1-6)	1425 (1350-1500)
Pinot Noir	9/11-10/20	6	4	2.6 (1.7-5.5)	1050 (1000-1100)
Others	9/13-10/18	23	27	--	--

Average Hand picking cost = $115/Ton (40-260)

**CSU Growers Survey*

Colorado Wine Grape Acreage

by Variety1997



1997
*Colorado Wine Grower Survey**

Variety	Harvest Date	% Acreage	% Yield	Ave. Yield T/A	Price ($/T)
Chardonnay	9/4-10/20	27	23	2.6 (1-10)	1194 (800-1400)
Merlot	9/9-10/14	24	25	3.9 (1-7)	1293 (1100-1500)
Riesling	10/3-16	8	8	3.6 (1-11)	800 (700-940)
Cabernet Franc	9/16-10/14	6	6	5.2 (4-7)	1387 (1300-1450)
Cabernet Sauvignon	9/20-10/18	6	7	4.2 (1-6)	1425 (1350-1500)
Pinot Noir	9/11-10/20	6	4	2.6 (1.7-5.5)	1050 (1000-1100)
Others	9/13-10/18	23	27	--	--

Average Hand picking cost = $115/Ton (40-260)

CSU Growers Survey

1997
*Colorado Wine Grower Survey**

County	Acres (% Total)
Mesa	90
Delta	9
Other	<1

51 vineyards surveyed ***Average size = 5.7 acres***

**CSU Growers Survey*

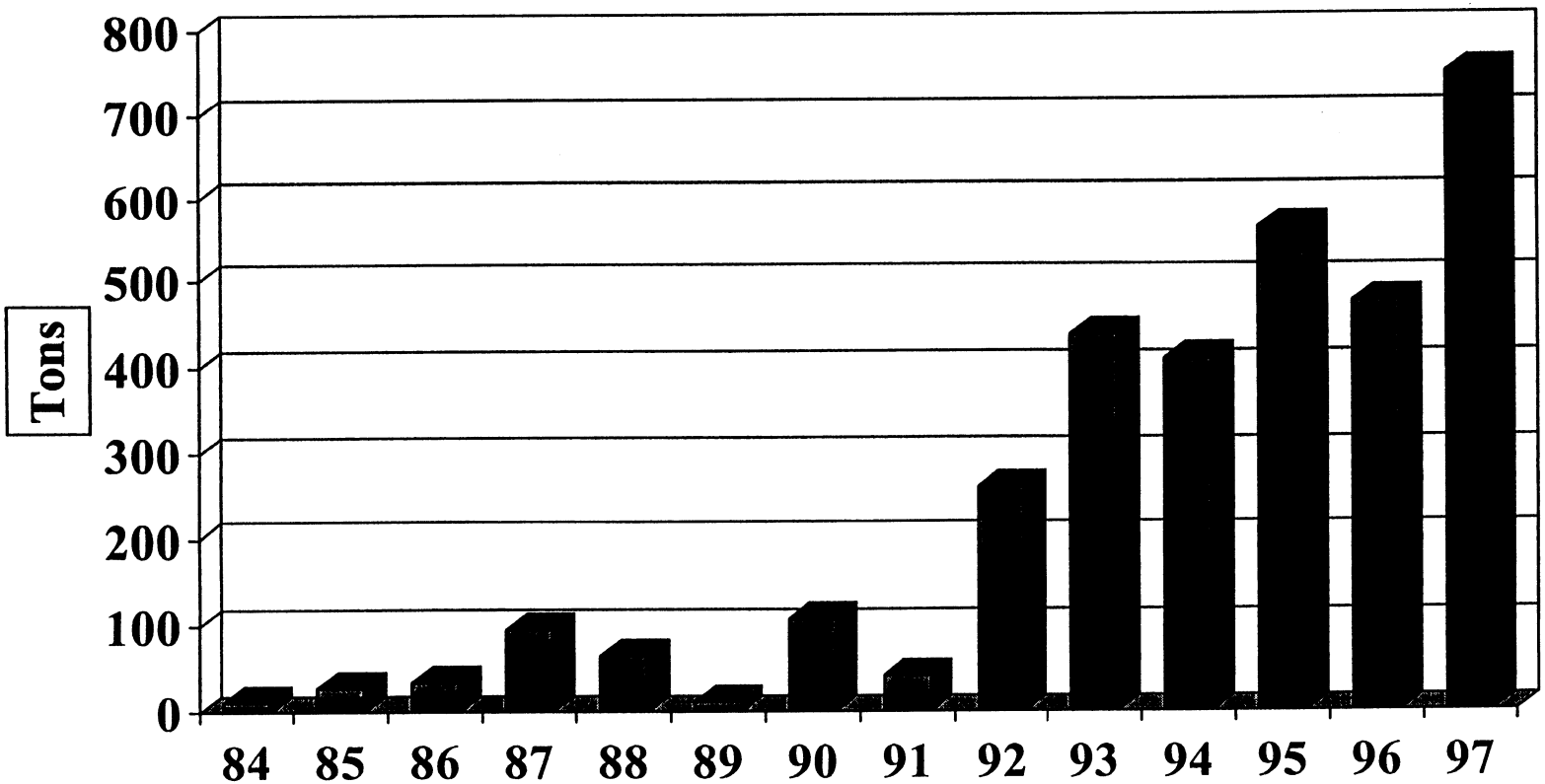
*Colorado Wine Grower Survey**
1997

Total Acres	Producing Acres	New Acres	Total Yield (Tons)	Ave. T/A
261	223	27	755	3.4

Tons sold to out-of-state markets = 114 (15%)

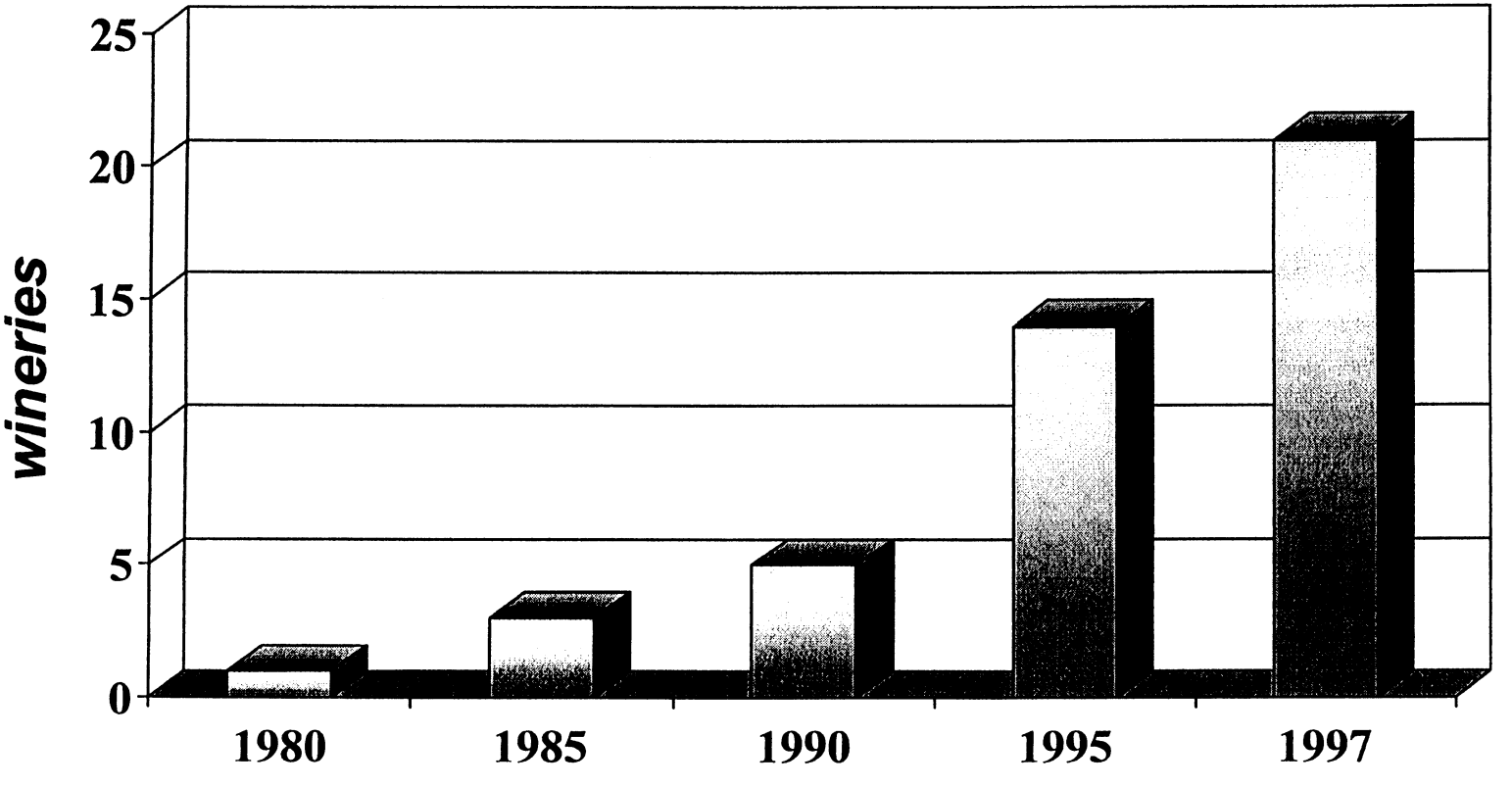
CSU Growers Survey

Colorado Wine Grape Production



CSU Grower Survey

Licensed Colorado Wineries



COLORADO STATE UNIVERSITY

Contacts and Resources for information on horticulture crops research and extension including wine grapes.

General/Administrative (in Ft. Collins)

	Phone
Kirvin Knox, Associate Provost for Agriculture and University Outreach/Dean, College of Agricultural Sciences	(970)491-6614
Lee Sommers, Director, Agricultural Experiment Station	(970)491-5371
Frank Johnson, Assistant Director, Agricultural Experiment Station	(970)491-7401
Milan Rewarts, Director, Cooperative Extension	(970)491-6281
Mary Gray, Associate Director, Cooperative Extension	(970)491-6281
Steve Wallner, Head, Dept. of Horticulture and Landscape Architecture	(970)491-7018

Viticulture/wine grapes

Rick Hamman, Orchard Mesa Research Center	(970)434-3264
Jan Sennhenn, Montezuma County	(970)565-3123

Note: Some of the specialists listed in the general fruit category (attached) may also be contacted regarding wine grapes.

Table 1. Colorado State University Fruit Resource List (Jan. 1, 1998)

Information Category	Resource Individual[1]	Location	Phone (Area Code 970)
Horticulture			
-NC/C	Curtis Swift	Tri-River Ext., G.J	244-1834
-C(all)	*Al Gaus	RMRC-Hotchkiss	872-3387
-C(Tree frt)	Matt Rogoyski	OMRC, Grand Jct.	434-3264
-C(Small frt)	Harrison Hughes	Campus, Ft. Collins	491-7050
-C(Grapes)	Rick Hamman	OMRC, Grand Jct.	434-3264
Diseases:			
-C[2]	*Harold Larsen	OMRC, Grand Jct.	434-3264
-NC	Plant Clinic[3]	Campus, Ft. Collins	491-6950
-NC	*Curtis Swift	Tri-River Ext., G.J.	244-1834
Entomology:			
-NC/C	*Gene Nelson	Tri-River Ext., G.J.	244-1834
-NC	Whitney Cranshaw	Campus, Ft. Collins	491-6781
-C	Rick Zimmerman	RMRC, Hotchkiss	872-3387
			872-5094
Irrigation:	*Dick Bartholomay	Coop. Ext./SCS, G.J.	242-4511
	*Dan Champion	Coop. Ext./SCS, G.J.	242-4511
	Israel Broner	Campus, Ft. Collins	491-6172
Farm Management:	Rod Sharp	Coop. Ext., Grand Jct.	245-9149
Pesticides/ Regulations	Sandra McDonald	Campus, Ft. Collins	491-6027
Weeds:	Scott Nissen	Campus, Ft. Collins	491-3489
Wildlife Problems:	Bill Andelt	Campus, Ft. Collins	491-7093

1 Individuals whose names are marked with an asterisk have more Cooperative Extension component ins their position and should be contacted first

2 Category codes: C = Commercial; NC = Non-commercial

3 All samples for the Plant Clinic should be submitted through your local CSU Cooperative Extension.

Colorado Plant Pathogenic Nematode Survey 1996-1997

Robert K. Niles
Gary A. McIntyre

Colorado State University

Database of Colorado Plant-Parasitic Nematodes

Robert K. Niles and Gary A. McIntyre
Natural Resource Ecology Laboratory, and Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, Colorado 80523

Contents

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Printout of information contained in the database. 21

Plant-Parasitic Nematode Information Included in the Database

Nematodes are the microscopic roundworms found in high abundances and high species diversity in the soils of natural and agricultural ecosystems. Many nematodes foster organic-matter decomposition and participate in the ecosystem service of nutrient mineralization. Such beneficial nematodes contribute to sustainable crop production in ways that are only beginning to be understood. In contrast with these nematodes, Colorado growers and agricultural experts are probably more familiar with the plant-parasitic nematodes that incite plant diseases and reduce crops yields. The sugarbeet cyst nematode has been recognized in Colorado for many years as a constraint on sugarbeet production.

For a variety of reasons, plant-parasitic nematodes have historically received less research and management attention in Colorado than in surrounding states. As a result, the incidence and impact of plant-parasitic species in the state's agriculture is less well known than it is elsewhere. To help fill this gap in knowledge, a database was developed to provide access to known information about plant-parasitic nematodes in Colorado.

Much of the information contained in the database resulted from surveys conducted in 1996 and 1997 of plant-parasitic nematodes in the state's agriculture (Table 1). The survey obtained information from five agricultural regions and 29 crops (Table 2). Survey data were supplemented by other sources of information. As a result, the database includes quantitative information about nematodes from soil and plants samples and qualitative information about nematodes from plant samples. Many of the quantitative soil samples originated from southwest Colorado (60%), followed by the northeast (18%), east central (15%), San Luis Valley (6%) and southeast (1%) (Table 3). These quantitative soil samples originated from field crops (41%), fruits (33%), vegetables(10%), and miscellaneous (16%) (Table 4).

Seventeen nematode taxa were detected in the quantitative soil samples (Fig. 1). Soil populations of *Pratylenchus* were high and frequently detected on all commodity groups (Fig. 1). *Paratylenchus* was high on field crops and fruits. *Tylenchorhynchus* could be high on vegetables. *Aphelenchoides* and *Aphelenchus* were frequently abundant on all commodity groups, but these nematodes are rarely economically important pathogens. Likewise, although abundances of *Helicotylenchus* could be high on fruits, this nematode would not be expected to influence yields.

Nine nematode genera were detected in quantitative soil samples from alfalfa hay (Table 5). Of these, *Pratylenchus* was common, followed by *Aphelenchoides*, *Paratylenchus* and *Tylenchorhynchus*. In addition, fungal-feeding *Aphelenchus* was present in most samples. A

diversity of plant-parasitic nematodes -- 12 taxa -- was detected on field corn, with the frequently detected genera including *Hoplolaimus*, *Pratylenchus*, *Trichodorus* and *Xiphinema* (Table 6). *Pratylenchus* was detected in over 50% of the samples from onion, potato and wheat (Tables 7-9). *Xiphinema*, which vectors plant viruses to fruit crops, occurred in more than half the samples from apple, cherry, grapevine and peach (Tables 10-13). In addition, over one third of the samples from apple, cherry and peach included *Meloidogyne* sp. Ring nematode (Criconematinae) is associated with yield loss of peach in the southeast, and on fruit crops in Colorado, this nematode was only detected on peach (Table 13). A richer diversity of nematodes was detected on turfgrass (13 taxa) than on landscape plantings (8 taxa) (Tables 14 & 15).

Quantitative and qualitative data on plant-parasitic nematodes are included in the database. Each data record is coded by region, county, commodity group, crop, nematode scientific name, and nematode common name. The benefits and uses of the database include:

•Documents the incidence and abundance of plant-parasitic nematodes occurring in Colorado.
•Provides preliminary data to: (1) identify potential nematode problems in the state's agriculture, and (2) determine how potential problems differ among regions and crops.
•Represents geography and agriculture at contrasting scales of resolution: geography represented as region and county; agriculture represented as commodity group and crop. In addition, for ease of use by a variety of clientele, nematode taxa are identified by scientific and common names.
•Online accessibility for crop consultants, extension agents, and growers who are located throughout the state and need nematode information.
•Generates on-the-fly responses to search requests. Thus, information about Colorado nematodes is disseminated in a timely way that meets the individual needs and queries of database users.

The online version of the database can be accessed at the following url:

http://www.nrel.colostate.edu:8080/~bobn/rkn.2b.NEMA.survey.html

A word of caution about using the database: the absence of information in the database about a particular region, crop or nematode does not imply the absence of a nematode problem. An advantage of the database design is the ease with which new data can be added. Nonetheless, management decisions about plant-parasitic nemtodes must be based on soil samples collected from a field in question.

Table 3. Inventory of samples received from Colorado locations.

Colorado region	Colorado county	Quantitative soil samples[1]	Quantitative plant samples[2]	Qualitative plant samples[3]
East central	Adams	9	0	0
	Arapaho	6	0	0
	Washington	1	0	0
	Yuma	30	23	0
	subtotal	46	23	0
Northeast	Boulder	1	0	0
	Larimer	15	0	0
	Logan	4	0	0
	Sedgwick	2	0	0
	Weld	35	0	0
	subtotal	57	0	0
San Luis Valley	Alamosa	11	0	0
	Rio Grande	8	0	0
	Saguache	1	0	0
	subtotal	20	0	0
Southeast	Bent	0	0	40
	Otero	4	0	23
	Prowers	0	0	18
	Pueblo	0	0	1
	subtotal	4	0	82
Southwest	Delta	47	0	0
	Mesa	99	0	0
	Montezuma	23	0	0
	Montrose	20	0	0
	subtotal	189	0	0
	total	316	23	82

[1]Quantitative soil samples expressed as nematodes per 100 cm^3 soil.
[2]Quantitative plant samples expressed as nematodes per gram dry plant root.
[3]Qualitative plant samples expressed as the presence or absence of nematodes in aboveground or belowground plant tissues (only those samples with nematodes present are included in the database).

Table 12. Results from quantitative soil samples from selected crops: soil-inhabiting nematodes detected by the Colorado Plant-Parasitic Nematode Survey in association with **grapevine**.

Nematode	n*	Percent occurrence	Nematodes / 100 cm^3 soil		
			Mean abundance	Standard error	Maximum abundance
Aphelenchoides	13	87	54	22	260
Aphelenchus	14	93	83	30	420
Criconematinae	.	.	.	.	.
Ditylenchus	4	27	16	5	27
Helicotylenchus	13	87	67	16	215
Hemicycliophora	.	.	.	.	.
Heterodera	1	7	44	.	44
Hoplolaimus	.	.	.	.	.
Longidorus	.	.	.	.	.
Meloidogyne chitwoodi	.	.	.	.	.
Meloidogyne sp.	1	7	5	.	5
Paratylenchus	7	47	97	30	215
Pratylenchus	11	73	28	13	155
Rotylenchus	.	.	.	.	.
Trichodorus	.	.	.	.	.
Tylenchorhynchus	11	73	20	4	45
Xiphinema	12	80	19	5	59

*n = total number of samples collected from grapevine = 15

Individuals who Contributed Data or Submitted Grower Samples

Bach, Bob
San Luis Valley Water Quality District P, 0881 North Highway 285, Monte Vista, CO 81144

Bartolo, Michael E.
Arkansas Valley Research Center, 27901 Road 21, Rocky Ford, CO 81067

Berrada, Abdel
Southwestern Colorado Research Center, 16910 County Road Z, P.O. Box 233, Yellow Jacket, CO 81335

Deroo, Kevin
Diamond Hill, 19009 Highway 392, P.O. Box 106, Lucerne, CO 80646

Fithian, Wayne
202 Lincoln, Sterling, CO 80751

Hamman, Richard A., Jr.
Orchard Mesa Research Center, 3168 B.5 Road, Grand Junction, CO 81503-9621

Herrera, Dave
P.O. Box 5134, Greeley, CO 80631

Jepson, Ronald F.
Adams County Cooperative Extension, 9755 Henderson Road, Brighton, CO 80601

Lancaster, Gary K.
Sedgwick County Cooperative Extension, 3rd & Cedar, County Courthouse, Julesburg, CO 80737

Larsen, Harold J.
Orchard Mesa Research Center, 3168 B.5 Road, Grand Junction, CO 81503-9621

Mejia, Susana
Adams County Cooperative Extension, 9755 Henderson Road, Brighton, CO 80601

Pearson, Calvin H.
Fruita Research Center, 1910 "L" Road, Fruita, CO 81521

Pilcher, Stanley D.
Golden Plains Area Cooperative Extension, 181 Birch, County Courthouse Annex, Akron, CO 80720

Schwartz, Howard F.
Department of Bioagricultural Sciences and Pest Management, E207 Plant Sciences Building, Colorado State University, Fort Collins, CO 80523

Simplot, Tim
P.O. Box 129, Gilcrest, CO 80623

Swift, Curtis E.
Mesa County Cooperative Extension Service, 2798 B Road, Unit B, P.O. Box 20,000-5028, Grand Junction, CO 81502-5028

Walker, Bradley and Cynthia
AgSkill Crop Services, 710 S 4th Street, Lamar, CO 81052-3418

Zimmerman, Rick
Rogers Mesa Research Center, 3060 Highway 92, Hotchkiss, CO 81419

Zink, Richard T.
San Luis Valley Research Center, 0249 E Road 9 North, Center, CO 81125

VITICULTURE RESEARCH AND EXTENSION PROGRAM SURVEY

The Colorado Wine Industry Development Board and our research contractor Colorado State University want to survey constituents in order to determine how well we are satisfying your needs and to seek input to be used in setting the direction of future programs.

The Colorado General Assembly specified the purpose of the Wine Board in House Bill 90-1068. "35-29.5-103 Colorado wine industry development board - creation - members. (1) There is hereby established a Colorado wine industry development board in the department of agriculture for the purpose of encouraging and promoting viticultural and enological research and experimentation to develop maximum yields and quality from Colorado lands suitable to the production of grapes for commercial wine production, to promote the marketing of wines and promote the integration of the Colorado wine industry as a component of the state's tourism program, and to serve as a resource for the entire wine industry of Colorado. The board shall exercise its powers and perform its duties and functions specified by this article under the department of agriculture as if the same were transferred to the department by a type 1 transfer, as such transfer is defined in the "Administrative Organization Act of 1968", article 1 of title 24, C.R.S.

Your cooperation in filling out this survey will assist us in improving future programs and services. The Colorado Department of Agriculture will prepare the tabulation of responses. Please use the enclosed envelope to return your completed survey. No postage is necessary.

Also, please be assured that all individual responses will be kept confidential by the Department of Agriculture. Tallied survey data may be provided to other organizations such as the RMAVV.

Please return this survey by February 20th.

Thank you.

Colorado Wine Industry Development Board

3168 B1/2 Road • Grand Junction, CO 81503 • Telephone (970) 523-1232 • Facsimile (970) 434-1035 • Web Site: http://www.coloradowine.com

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In which part(s) of the wine industry are you an active participant?
Wine Grape Producer____ Licensed Winery____
Vineyard Acreage (Please circle one): less than 1 acre; 1-5 acres; 6-15 acres; 16+acres.

Part I: Viticulture

Please rate each of the following in accordance with its importance to you with 5 being the most important.

	Lowest				Highest
1.) Workshops related to growing grapes	1	2	3	4	5
2.) Site selection	1	2	3	4	5
3.) Planting information	1	2	3	4	5
4.) Bud break information	1	2	3	4	5
5.) Grape pruning information	1	2	3	4	5
6.) Canopy management	1	2	3	4	5
7.) Trellising information	1	2	3	4	5
8.) Irrigation information	1	2	3	4	5
9.) Nursery information	1	2	3	4	5
(Over)					
10.) Crop size information	1	2	3	4	5
11.) Disease, insect, vertebrate control	1	2	3	4	5
12.) Rootstock research	1	2	3	4	5
13.) New varietal research	1	2	3	4	5
14.) Vineyard floor management	1	2	3	4	5
14.) Fertigation, fertilizer, nutrient information	1	2	3	4	5
15.) Cold hardiness research	1	2	3	4	5
16.) Vineyard machine information	1	2	3	4	5
17.) Grower survey information	1	2	3	4	5
18.) Migrant workers (speakers, labor source lists)	1	2	3	4	5
19.) Basic lab workshops for growers (explain Brix, pH, acidity)	1	2	3	4	5
20.) Other: _____	1	2	3	4	5
21.) Other: _____	1	2	3	4	5
22.) Other: _____	1	2	3	4	5
23.) Other: _____	1	2	3	4	5

Part II: Enology

Please rate each of the following in accordance with its importance to you with 5 being the most important.

1.) Wine making techniques workshops	1	2	3	4	5
2.) Wine color enhancement research	1	2	3	4	5
3.) Winery operation	1	2	3	4	5
4.) Wine tasting and evaluation	1	2	3	4	5

5.) Suggested seminar topics (please list)

a.) _____
b.) _____ 1 2 3 4 5
c.) _____ 1 2 3 4 5
1 2 3 4 5

Part III:

1.) What *assistance* do you want from the viticulturist? Be specific.

_____

_____

2.) Would you be interested in a workshop in which grape growers and winemakers would work together to develop a better understanding of what wine makers want from grape growers and vice versa? YES _____ NO _____

3.) From all the topics previously mentioned in this survey (including your own suggestions), please select and rank the five which are most important to you.

A.)(most important) _____
B.) _____
C.) _____
D.) _____
E.) _____

4.) Do you have any other comments for the Wine Board and/or Colorado State University? (attach additional pages, if necessary)

_____

_____

_____

_____

_____

Thank you for completing the survey. Please return it in the enclosed, postage-paid envelope to: Colorado Department of Agriculture
Markets Division, Attn: Jim Rubingh
700 Kipling Street, Suite 4000
Lakewood, CO 80215-5894

_____

(to be detached by Colorado Department of Agriculture)

Respondent:

Name:_____
Address:_____
_____

VINEYARD NEWS

Rick Hamman - Viticulturist
Colorado State University, OMRC
3168 B1/2 Rd. Grand Junction, CO 81503
970-434-3264

Vol. No. 1
June 3, 1998

Grapevine tissue Analysis

Routine tissue analysis is a useful tool vineyard managers can use to reveal the concentration of essential nutrients within the vine tissues. It can take the guesswork out of visually diagnosing nutritional deficiencies and vineyard fertilization.

When to Sample:

Collect samples at full-bloom for routine nutrient assessment. Non-routine "trouble-shooting" can be done throughout the season to help identify possible deficiences.

What to Sample:

The leaf petiole. The petioles are the slender stems connecting the leaf blade to the shoot. Collect the petioles from leaves opposite the blossom clusters towardas the base of the shoot. A collection sample should not represent more than 5 acres. A representative sample for a routine analysis consists of 75 to 100 petioles (one per vine). Collect the petioles into a labeled paper bag.

Where to Send Samples:

Several labs throughout the country offer tissue analysis for nominal fees. Below are several reliable labs who process and return the results in a relatively short time period.

California Growers Laboratory Inc..
4630 W. Jennifer
Fresno, CA 93722
1-209-275-3377

A&L Analytical Laboratories, Inc.
411 North third street
Memphis, TN 38105-2723
1-800-264-4522

Colorado State University
Soil/Plant Testing Laboratory
A319 Natural and Environmental Sciences
Ft. Collins ,CO. 80523
1-970-491-5061

Interpretation and Fertilizer Recommendations:

Most labs provide general recommendations (usually for a little extra cost) but if you would like me to provide fertilizer recommendations, send a photocopy of the analysis results to me here at the Orchard Mesa Research Center.

Shoot Thinning:

Shoot thinning is the removal of unwanted shoots. Grapevines typically produce more shoots than the buds left at winter pruning and consequently shoot overcrowding can occur. Clusters often accompany the overcrowded shoots and thinning becomes necessary. Shoot thinning on moderately vigorous vines for maximum air and sun exposure of fruit and shoots should begin when new growth has reached about 15 inches and can continue until a couple of weeks after berry set. New shoots may be forced to grow if shoot thinning is carried out too early. If shoot thinning is too late, the redirected growth(energy) is of less benefit to the desired shoots. Grapevines are commonly thinned along the cordon wire so that they are evenly spaced at a distance of 3 to 5 inches or about 5 shoots per foot.

by
Rick Hamman, Viticulturist

Vineyard Growth and Fruit to Wood Ratios

Pruning weights are absolutely necessary for evaluating annual vineyard growth.

Measuring fruit weight is an automatic procedure in the vineyard, but measuring pruning weight is unfortunately overlooked too often. Pruning weights are absolutely necessary for evaluating annual vineyard growth. Keeping records of fruit weight per vine and pruning weight per vine go hand in hand. The information gathered from these two measurements give an indication of vineyard growth. Vineyard growth is expressed as a balance between fruit production and vegetative growth. Vineyard growth is an actual ratio of fruit weight to pruning weight. The following example is from 1996 Chardonnay vines, grown at the Orchard Mesa Research Center, that produced 6.1 tons per acre.

Calculating fruit weight to pruning weight ratios:

Fruit Weight = 13.5 #/vine

Pruning Weight = 1.73 #/vine

$$\textbf{Ratio} = \frac{13.50}{1.73} = \frac{7.8}{1}$$

Fruit to wood ratios of 6:1 to 8:1 are ideal.

This ratio indicates that for every 7.8 pounds of fruit there is 1 pound of pruned wood, a well balanced vine. Years of research and practical experience have pretty well proven that the optimum ratios of fruit to wood will be between 5:1 to 10:1 for a wide range of vineyard situations. Fruit to wood ratios of 6:1 to 8:1 are considered ideal.

Very low fruit to wood ratios of 1, 2, or 3:1 indicate a poorly balanced vine with excessive growth (too much vegetation). Excessive growth can result in higher disease incidence and fruit shading which reduces sugar, color, phenolic compounds and can produce undesirable vegetative flavors. High fruit to wood ratios of 12, 15, or 20:1 indicate the vines were overcropped. Overcropped vines will have trouble ripening and can become easily sunburned. In Colorado, overcropping late maturing cultivars can be a mistake for vineyard sites with short growing seasons.

If you find your vines are out of balance, then corrective action needs to take place.

Winemakers only want the highest quality fruit. If you send the winery a load of fruit from a poorly balanced vine, chances are penalties will be imposed or the entire load may be rejected. If you find your vines are out of balance, then corrective action needs to take place. Overcropped vines can be dealt with by decreasing the amount of wood left when pruning and or cluster thinning after bloom. Excessive growth can be dealt with by increasing the amount of wood left

when pruning and or dividing the canopy. The decision to divide your canopy because of excessive vigor usually requires retrofitting your current trellis system. This can be expensive and may be the only answer, but exhausting all alternatives should be considered first. If your vine density is high and the vines are overcrowded, removal of every other vine may be necessary. Over irrigated vines can produce excessive vegetation. Adjustments to your irrigation practices can help reduce growth.

Measuring pruning weights of 4% of the vines per acre will be adequate.

Pruning weights are very easy to measure and only require pruning shears and a scale that will weigh up to 5 pounds. The procedure is simple; prune the vine as normal and weigh the wood you removed. The more vines you prune and weigh, the better your accuracy. For practicality, measuring pruning weights of 4% of the vines per acre (e.g. 35 vines @ 871 vines/acre) will be adequate. Randomly choose healthy vines of uniform age and size that you feel fairly represent the vineyard. Flagging those vines will allow for easy, accurate, and consistent measurements year after year.

Now is the time to measure your vineyard growth and plan for necessary adjustments. Remember, measuring vineyard growth via fruit to wood ratio is important because:

1. It is an accurate measure of vine growth.
2. It will help identify problem areas.
3. It aids in management decisions/adjustments.
4. It is easy, reliable and inexpensive.

National Organic Program - Proposed Rule Comment Period Extended

The new deadline for comments is now April 30, 1998

The U.S. Department of Agriculture (USDA) has a proposed rule and all interested individuals will have the opportunity to make a comment on this rule. The closing period for comment has been extended to April 30, 1998.

We will still devote the March 5th, Rogers Mesa Research Center brown bag lunch to this topic. We will present the available information at that meeting and inform you how you can comment on the proposed rule if you so wish. (Gaus)

The Colorado Grapevine

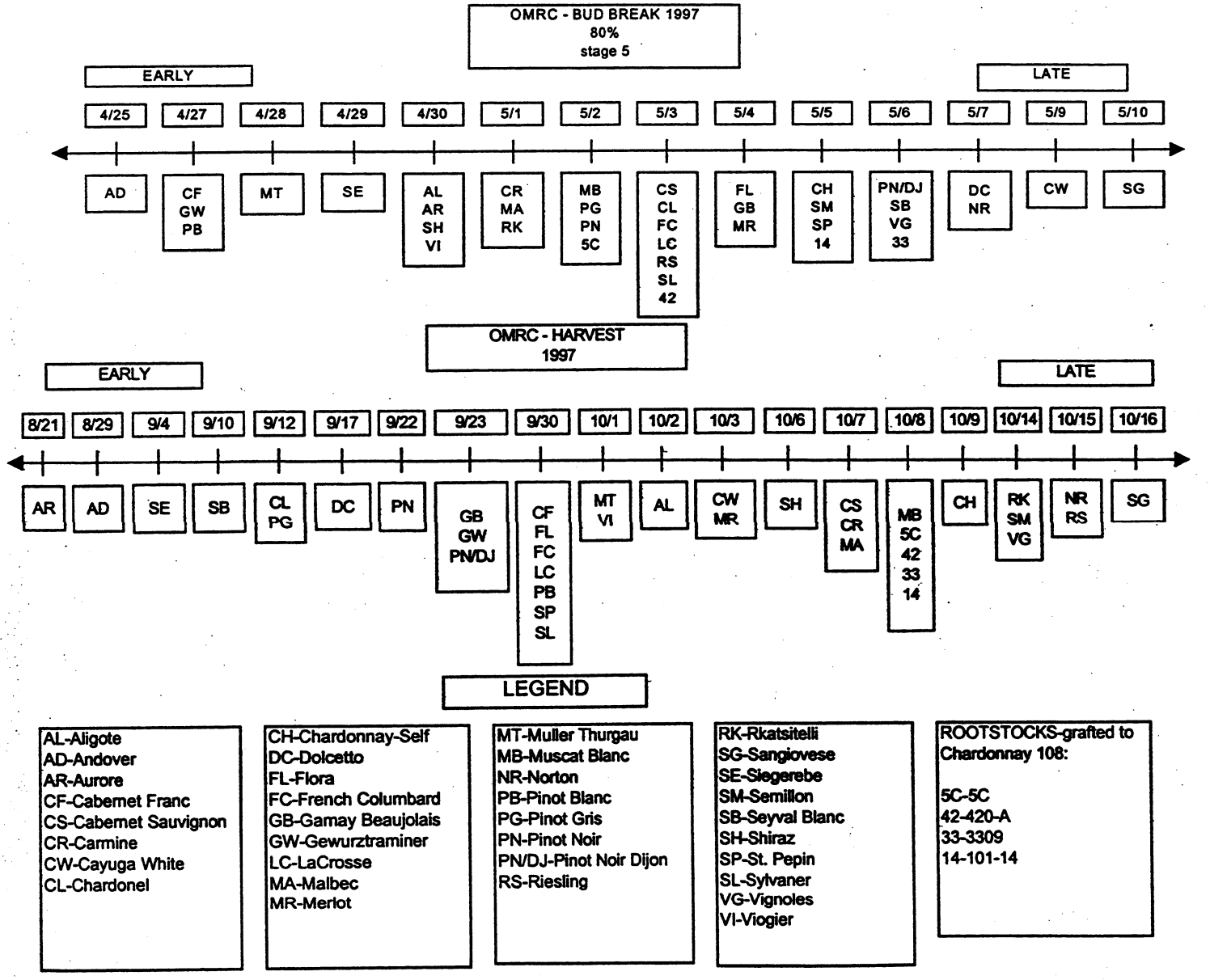
By

Rick Hamman

Cultivar trials at OMRC:

One of the responsibilities of the viticulture program at OMRC is to provide Colorado grape growers with a better understanding of the specific limits of grape production and wine quality in this area. The viticulture program is currently addressing these issues through yearly cultivar evaluations. A summary of the 1997 Bud Break and harvest dates for 34 cultivars and 4 rootstocks grown at OMRC is presented. Data of this kind is helpful to growers when deciding what cultivar to plant in a particular site. If you have questions regarding this cultivar information or would like more details about cultivar selection please contact me at 970-434-3264.

Note that the actual bud break "stage" of development was determined by using the Eichhorn-Lorenz 1977 method..Stage 5 is when the emerging green shoot is clearly visible. The actual date of bud break is when 80% of the vine reaches stage 5.



The Colorado Grapevine

Imed Dami and Rick Hamman

How to Estimate Grape Yields

At this time of the year, most growers have already estimated their crop and made contract commitments with wineries. Although, it seems too late for crop estimation, there are still a bunch of numbers that need to be collected by growers prior to season's end. Before we discuss what we mean by that, let's define crop estimation. Crop estimation also called crop prediction is the process of projecting as accurately as possible the quantity of crop that will be harvested. Why estimate the crop? Obviously, growers need to know how much crop they produce. Also, growers would like to know whether their vines are overcropped or undercropped in order to conduct the necessary adjustment. This is especially important in cold areas such as Colorado where winter freeze and spring and fall frosts could change the crop quantity each year. Fortunately, this year the Western Slope did not experience the "Siberian Express" and the spring frost damage was at worst minimal.

In this article, we describe the most popular and easy to understand system to estimate yield. This system is used successfully in other winegrape growing regions of the country. Growers interested in trying this system should begin collecting data this season. Also, growers need to bear in mind that this system provides only an "estimate" of yield which should never be considered "final". Components of yield vary each year depending on the year, site, variety, and cultural practices. The following formula can be used to estimate crop with reasonable accuracy:

$$PY = (NV \times NC \times CW) / 2000$$

Where PY = predicted or estimated yield (in tons per acre)
NV = actual number of vines per acre
NC = number of clusters per vine
CW = cluster weight (in pounds).

According to the formula, the grower needs to measure 3 parameters each year; the actual number of vines per acre, the number of clusters per vine, and the cluster weight. These parameters are discussed below with examples.

1) Actual number of bearing vines per acre: the maximum number of vines per acre is determined by the row and vine spacing. For example, a spacing of 5 x 10 feet vineyard will have 871 vines per acre. Almost always the "actual number" is lower than the "maximum number" of vines per acre due to missing vines for several reasons such as diseased vines, winter-injured

vines, etc. For these reasons, each year, growers need to physically count the missing vines, subtract that number from the maximum number to get an accurate count of bearing vines. If 10% of the 871 vines/acre (i.e. about 87 vines) were missing or nonbearing then the actual number of bearing vines/acre is 871 - 87 = 784.

2) Number of clusters per vine: this number will depend on how many nodes (buds) are left after pruning. Counting clusters per vine can be determined as soon as they are visible (i.e. two weeks before bloom) or as late as berry set (i.e. BB size stage). The advantage of early count is that clusters are readily visible and are not obscured by leaves. The number of vines on which to count clusters depends on vineyard size and uniformity. For example, in 1 to 3 acre-vineyard with vines of a uniform age, size, and pruned to the same bud number, only 4% of the vines need to be counted. For practicality, 10 to 20 vines could be used; however, growers need to bear in mind that the higher the number of vines selected for cluster count the more accurate the yield estimate will be. In larger, non-uniform vineyards, more vines should be selected. All the clusters on the sample vines should be counted. Also, the vines should be selected methodically; e.g. select every 10th vine in every other row.

3) Cluster weight: is the component of yield that varies the most from year to year. It is influenced by environmental conditions. For example, wet weather during bloom could cause poor set and may lead to low cluster weight; also a dry summer tends to reduce berry size and thus may decrease average cluster weight. Other factors that may affect cluster weight include cultural practices (irrigation, fertilizers), diseases, insects, and birds. Cluster weights at harvest are a key part of any yield prediction program. The goal of obtaining cluster weight at harvest is not to predict the yield that year, but to provide records for yield prediction in subsequent years. Clusters can be collected from picking bins after harvest. This is an easy way to sample clusters from the bin but not as accurate as sampling clusters from the vines. The same vines used for cluster counts could be used for cluster weights. Clusters from each sample vine are picked then weighed. The average cluster weight is obtained by dividing the total cluster weight per vine by the number of clusters per vine. Growers who do not have these data (hopefully will in the future!) could use estimates of cluster weights shown in the table below (source: CSU-OMRC and Washington State University).

4) Example of predicted yield of Chardonnay for 1997 harvest at OMRC:

- spacing = 5 x 10 feet or 871 vines/acre
- missing/nonbearing vines = 1% or about 9 vines/acre
- actual number of bearing vines = 871 - 9 = 862 vines/acre
- average cluster count = 45 clusters/vine
- average cluster weight (based on 1996 harvest) = 0.3 lbs
- predicted yield = (862 x 45 x 0.3) / 2000 = 5.8 tons/acre

Even with thorough sampling, accurate vine counts, and many years average cluster weight data, the actual crop tonnage at harvest can vary significantly from that which is predicted. Our experience during the last 6 years has shown that we are able to predict yields with 75-85%

accuracy using this system. Accurate yield predictions, therefore, require long-term records and an understanding of the causes of yield variation. We encourage growers not to be discouraged if first attempts at crop estimation are inaccurate, because the more experience and data acquired, the more accurate the estimates will become. Good luck with harvest and do no forget to collect data on cluster weight this year.

Table. Average cluster weights for wine grape varieties in Washington and Colorado.

Variety	Cluster Wt. (lbs) in WA	Cluster Wt. (lbs) at OMRC*
Whites:		
Chardonnay	0.3 - 0.45	0.3
White Riesling	0.25 - 0.3	0.34
Gewurztraminer	0.25- 0.3	0.2
Semillon	0.4 - 0.5	0.46
Muscat blanc	0.4 - 0.5	0.57
Viognier	--	0.27
Sauvignon blanc	0.25 - 0.3	--
Pinot blanc	--	0.3
Chardonel	--	0.23
Seyval blanc	--	0.24
Vignoles	--	0.18
Reds:		
Merlot	0.3 - 0.45	0.36
Cabernet Sauvignon	0.3 - 0.4	0.27
Cabernet franc	0.4 - 0.45	0.29
Pinot noir	--	0.34
Shiraz	--	0.28
Sangiovese	--	0.61
Dolcetto	--	0.4
Malbec	--	0.36
Norton	--	0.12
Lemberger	0.4 - 0.5	--

* Cluster weights taken at OMRC are based on 1996 harvest data.

The Colorado Grapevine
by
Rick Hamman

1997 Grape Powdery Mildew trials at OMRC.

Powdery mildew (Uncinula necator) is the most serous disease of wine grapes in Colorado. Infection can occur in most vineyards if control measures are not employed. Powdery mildew can lower wine quality; consequently, most wineries will financially penalize a grower or deny the entire load if appreciable mildew is present. Powdery mildew (PM) is easy to control if proper timing of fungicide application is observed. Powdery mildew prevention must occur before the fungus is actually visible. Waiting until visible signs of the fungus forms on the leaves or clusters is too late to prevent infection. The most highly recommended fungicide programs for grape powdery mildew control begin at bud break and continues on a rigid schedule. Starting your fungicide program too late or having long spray intervals are powdery mildew management mistakes that should be avoided. The 1996 Colorado Grape Growers Guide has a powdery mildew schedule that if followed will provide proper management of PM infection in your mature vineyard.

The viticulture program at OMRC has been evaluating several alternative bio-control materials for grape powdery mildew control. Chemical control of PM in Colorado vineyards has been focused on two classes of fungicides, inorganic sulfur as wettable powder formulations and DMI (demethylation inhibitor) fungicides (Bayleton, Nova, Rubigan, etc.). Theses fungicides have worked well for most vineyards but some drawbacks such as, sulfur phytotoxicity, decreased sensitivity of powdery mildew to DMI fungicides and the continued loss of fungicides from EPA regulations have inspired us to set up this small grape powdery mildew trial.

This field trial was established at OMRC in the 6 year old Chardonnay test vineyard. The vineyard has a row by vine spacing of 10' X 5' and was spur-pruned and trained to bilateral cordons on a vertical shoot positioned trellis. All plots were established in a randomized complete block design with 3 replications of 40 vines each.

The chemicals applied, rate, timing of application, cost per acre, and percent infection (leaf, cluster, and cane) are shown in table 1. All treatments were applied using an over the row tunnel sprayer operating at a pressure of 150 psi. The treatments and spray intervals consisted of the following: M-Pede (Mycogen Corp., San Diego, CA) at a12 -14 day interval, sunflower oil (International Flora Technologies, Apache Junction, AZ.) at a 12-14 day interval, Stylet Oil (JMS Floral Farms Inc., Vero Beach, FL.) at a 12- 14 day interval, micronized sulfur (Thiolux by Sandoz Ltd.) at a 10 - 14 day interval, and Nova (Rohm and Haas Co.) at a 14 - 18 day interval. Treatments began at the initiation of shoot elongation (May 14) and continued through the season at 12 - 18 day intervals depending on the fungicide used. All treatments ceased at veraison August 10 and cluster and leaf evaluations were made on August 28, 1997. Dormant canes were evaluated November 5, after leaf fall. Clusters and canes were counted in the field

for percent disease incidence of powdery mildew. Disease incidence was expressed as the percent of clusters or canes with any powdery mildew. Loaf powdery mildew incidence was estimated as a percent of whole vine canopy infection.

Table 1. Treatments and results of powdery mildew fungicide trial on Chardonnay grapevines at Orchard Mesa Research Center, Grand Junction, Colorado 1997

Treatment[d]	Rate/100 gals.	Application dates[c]	Powdery mildew (%)[b] Cluster Incidence	Leaf Incidence	Cane Incidence	Cost/acre[a] $
M-Pede	1.5 gal./100	May 14,27, June 12,27 July 14,29, Aug. 8	<1	2.6	3	795
Sunflower Oil + Joy Soap[e]	1.0 gal./100 + 2 oz./100	May 14,27, June 12,27 July 14,29, Aug. 8	1.3	6.5	4.6	118
Thiolux-Sulfur-Nova-DMI	5#/100 2.5 oz./100	May 14,27, June 16, July 8,29, Aug. 8	0	<1	0	44
Stylet Oil	1.5 gal./100	May 14,27, June 12,27 July 14,29, Aug. 8	<1	1.2	0	73
Control	unsprayed		8	50	41	

[a] Cost per acre is based on materials only at a rate of 100 gallons per acre.
[b] Disease rating made August 28 for clusters and leaves, canes were rated November 5. Values represent means of three replicate plots per treatment.
[c] Initial application was at bud break
[d] No discrimination or endorsements are implied by CSU with the material trade names used in this trial.
[e] Joy soap was added to the sunflower oil as an emulsifier.

Results:

The standard powdery mildew control program of sulfur and Nova reduced the PM incidence more and cost less per acre compared to all other treatments. The high grade paraffinic mineral oil JMS Stylet Oil, used at a concentration of 1.5% v/v, was slightly more effective at controlling cluster, leaf and cane PM incidence than either sunflower oil or M-Pede. Sunflower oil was the least effective bio-control material and M-Pede was by far the most expensive material to use. Sunflower oil was also difficult to maintain a tank emulsion even with the addition of Joy soap as an emulsifier. M-Pede produced excessive foam in the tank. JMS Stylet oil, M-Pede and sunflower oil all function as contact fungicides of PM and therefore require shorter spray intervals and more thorough coverage than with the systemic DMI Nova. Oil spray intervals of 12 -14 days appeared adequate for this trial considering the environmental conditions were optimum for PM development

This trial numerically demonstrated reduced incidence of PM infection to clusters, leaves and shoots of Chardonnay grapevines by using several bio-control materials when compared to unsprayed controls. The results of this PM trial provide us with some direction for 1998 trials which will focus on Stylet oil concentrations, sprayer application pressures and PM program combinations of Stylet oil and DMI.

The Colorado Grapevine

Rick Hamman

Grape Powdery Mildew

Grape powdery mildew (*Uncinula necator*) is a native to the eastern U.S. on various *Vitis* species which occur there. In the mid-1800's it spread to Europe through England where it began to cause serious economic problems on the European grape, *Vitis Vinifera*. It is now found in all grape growing areas of the world and annual control expenditures are approximately $250 million world wide.

Powdery mildew is the most serious disease facing wine grapes in Colorado. Infection can occur in most vineyards if control measures are not employed. Powdery mildew (PM) can lower wine quality; consequently, most wineries will penalize a grower or deny the entire load if appreciable mildew is present. The loss of the crop and production costs can easily be prevented with proper management.

The organisms which cause what are called "powdery mildew" diseases belong to an unusual group of fungi called the Erysiphales. They are distinguished by several features. They are obligate parasites which means that they can only grow and reproduce on a living plant host. They are much more independent of moisture for their growth and particularly for the process of spore germination. Nearly all fungal pathogens require at least a film of free water in order to germinate and infect a plant, but powdery mildew fungi do not. They are favored by higher humidities, but can function at remarkably low humidities in many cases. Powdery mildews tend to be very host specific. For instance, the powdery mildew which infects grape (*U. necator)* only infects a few other plants while the powdery mildew which infects apples cannot infect grape.

PM prevention must occur before fungus is actually visible. PM prevention can be achieved if proper timing of fungicide application is observed. The following PM schedule is reprinted from the Colorado Grape Growers Guide and may help control the level of PM infection in your mature vineyard. Read the label and observe rates and regulations of all pesticides.

Standard Fungicide Programs

The most highly recommended fungicide programs for grape powdery mildew control are as follows:

Standard DMI (Demethylase Inhibitor fungicides ie, Nova, Rubigan, Bayleton, etc.) Program:

1. Wettable or dusting sulfur starting at budbreak and continuing on a 10-14 day pattern (7 days for dust) until bloom or 10" shoot growth.

2. DMI applications every 18 days from bloom or 10" shoot growth until the total, annual dosage/acre has been applied (usually around 3 sprays).

3. Sulfur applications on a 10-14 day interval (7 day interval for dust) until veraison.

Standard Sulfur Program:

1. Wettable sulfur starting at budbreak.
2. Dusting or wettable sulfur on a 7-14 day cycle until veraison.

Older recommendations (first written in 1905) began the program at 6 or 12 inches of shoot growth, but recent research indicates that much better control is usually achieved by starting the spray program earlier.

These programs are commonly modified by grape growers for various reasons.

DMI program modified for resistance management:

- Alternation: sulfur sprays inserted between the DMI applications.
- Tank mixing: sulfur added with the DMI applications.
- Substitutions: the total number of DMI applications reduced to 2 or 1 with sulfur used to cover the interval.

The most common errors and problems in mildew management:

It would be rare to find someone who has grown grapes for several years who has not at some point been "caught" by mildew. The epidemic is explosive and it is easy to have flaws in a mildew program which allows the disease to break through. Also, mildew pressure varies from season to season. A program which is completely adequate one year may not stop the disease in a year which is particularly conducive for disease development (e.g. mild winter, early spring rains, relatively cool summer conditions). Powdery mildew management mistakes usually fall into the following

categories:

1. **Starting too late:** new recommendations for mildew control begin at budbreak; this is particularly important in some areas where there is significant over-wintering inoculum. This can happen to even the best intentioned grower since some vineyards can be too wet to allow entry of spraying equipment at the beginning of the season.

2. **Severe over-wintering infection:** in certain areas, over-wintering by cleistothecia is so common that a serious battle with the disease starts at budbreak. This is not common except in some coastal areas of California.

3. **Long spray intervals:** it is very easy to let mechanical failures, bad weather (rain, wind) or holidays combine to interfere with fungicide applications in the early season. A planned 10-day interval can easily slip to 16 or 18 days. With the rapid growth of the vine in the early summer, this allows the disease epidemic free reign and makes subsequent control difficult.

4. **Wrong fungicide:** this is usually only a problem with inexperienced growers. Copper, Mancozeb, Ronilan or Rorval do NOT provide significant control of powdery mildew.

5. **Tolerant Strain:** in some areas, mildew populations are now very difficult to control with DMI (Demethylase Inhibitor) fungicides because of previous selection for resistance.

Harvest:

A record harvest is anticipated for 1997. Wine grape production is likely to be over 600 Tons. Record rainfalls and a cool September have delayed harvest and severely increased powdery mildew infections in many vineyards. Harvest dates for most varieties appear 2-3 weeks later than last season.

Calendar:

November 15, 1997 - Rocky Mountain Association of Vintners and Viticulturists (RMAVV) meeting. 8:30 A.M - 4:00 P.M at the Country Inn Grand Junction, CO. Contact Marice Doll (303-756-4624) or Phyllis Gisler (970-464-7667) for more information.

The Colorado Grapevine

Rick Hamman and Imed Dami

Record Keeping in the Vineyard

Good record keeping is an integral part of grape growing. It is an extremely important method that will help grape growers improve cultural practices for years to come. Therefore, record keeping is a good habit that we encourage all growers to develop, since we believe that record keeping may have an immediate effect on the quality and quantity of Colorado winegrapes. The example of record sheet below addresses 5 critical areas of vineyard management during the growing season . These critical areas are pest control, weed control, fertilization, irrigation, and canopy management (not in order of importance). It is assumed that the trellis system is already established and the grapevines are producing. Harvest records are purposely not included on this sheet because those records are dealt with separately. The details of each cultural practice are available in the Colorado Grape Grower's Guide. Please feel free to contact us regarding this matter for any questions or suggestions at (970) 434-3264.

Example of vineyard management record keeping at OMRC - 1997

- Variety: Chardonnay
- Year planted: 1991
- Soil: heavy (clay loam) medium (loam) light (sandy)

Cultural Practices	Date- Stage[1]	Date- Stage	Date- Stage	Date- Stage	Date- Stage	Date- Stage	Date- Stage	Date- Stage	Date- Stage	Date- Stage	Comments[2]
1) Pest control - Powdery mildew (x) - Others Mealy bug (x) _____ _____	5/14-A 5/7-A	5/27-B 6/3-C	6/12-D								- sulfur (Thiolux) - Nova - treatment against mealy bug: Provado, Guthion - noticed honey dew (6/2) on trunks from mealy bug
2) Weed control - Mechanical (x) - Chemical	4/15-A	5/10-A	5/30-C								- Clemons hydraulic hoe - weeds no higher than 6 inch - cover crop mowed 2x
3) Fertilization - Nitrogen (x) - Others Fe-chelate (x) _____ _____	5/15-A 5/21-B										-Ammonium sulfate at 25#/A = 2.3 oz/vine - Fe-chelate spot-treated: 1oz/vine
4) Irrigation - Drip (gal/vine) (x) - Furrow (hrs/set)	5/8-A	5/13-A	5/16-B	5/20-B	6/2-C	6/6-D	6/13-D				- drip; 8L/hr emitters - 17 Gal/vine/week
5) Canopy management - Shoot thinning (x) - Cluster thinning - Leaf thinning - Shoot positioning (x) - Hedging	5/30-C to 6/15-D 6/10-D										- even growth - dense canopy - normal bloom, cool temp. - catch wires moved 6 inch up

[1]Stage of development: **A**, dormant bud - ½ inch growth; **B**, 2-6 inch growth; **C**, 10-20 inch growth; **D**, bloom; **E**, berry set (BB size); **F**, 2-4 weeks after berry set; **G**, veraison (color change of berries); **H**, 2 weeks after veraison

[2]Include information such as chemicals used, weather data (rain, temperature, wind), petiole analyses, stress symptoms, abnormalities, etc.